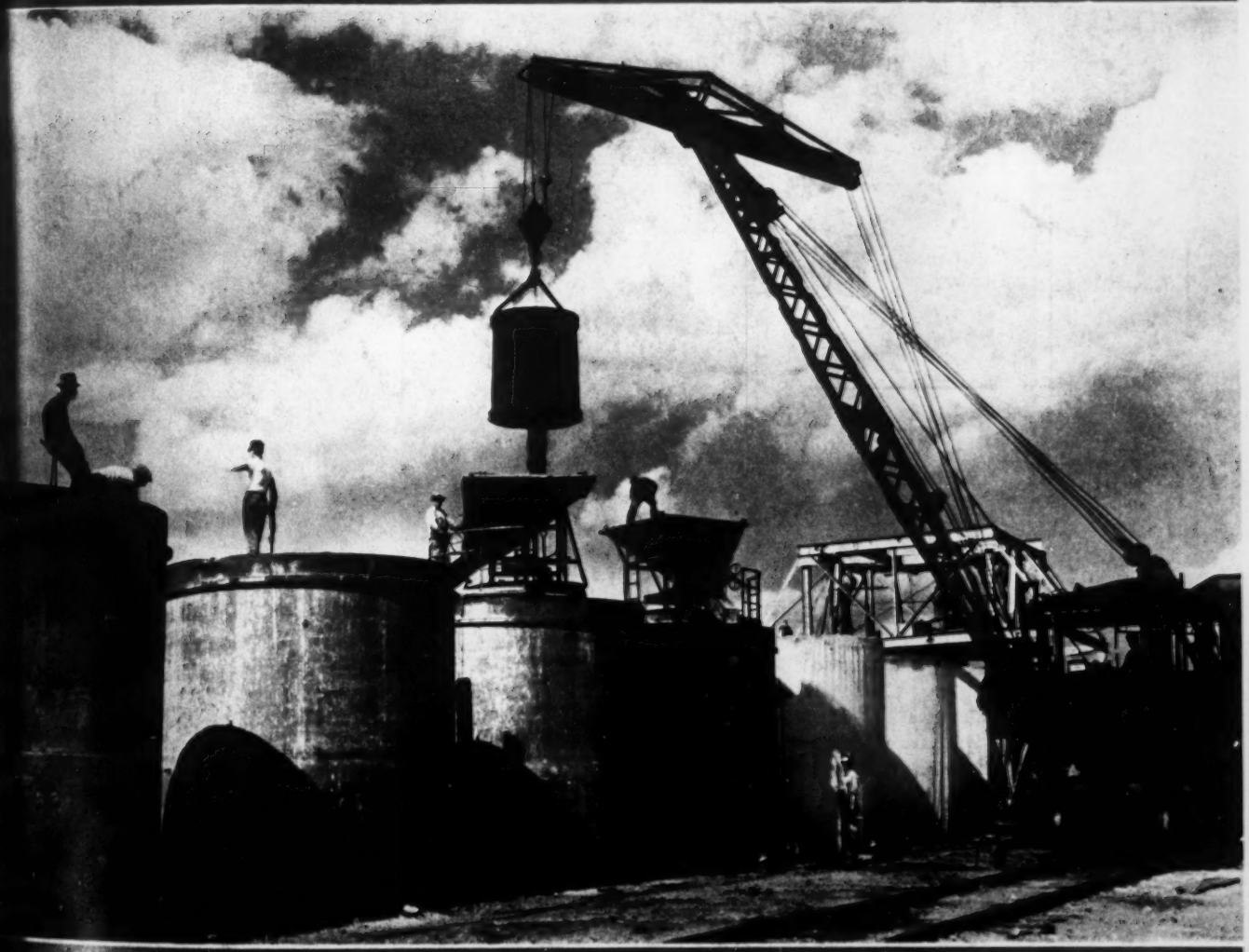
ENGINEERING CONSTRUCTION—WEEKLY

ENGINEERING NEWS-RECORD

AUGUST 31, 1939



OULD WPA CONTINUE IN CONSTRUCTION?

Opposing Views by F. C. Harrington and W. A. Klinger - see p. 60

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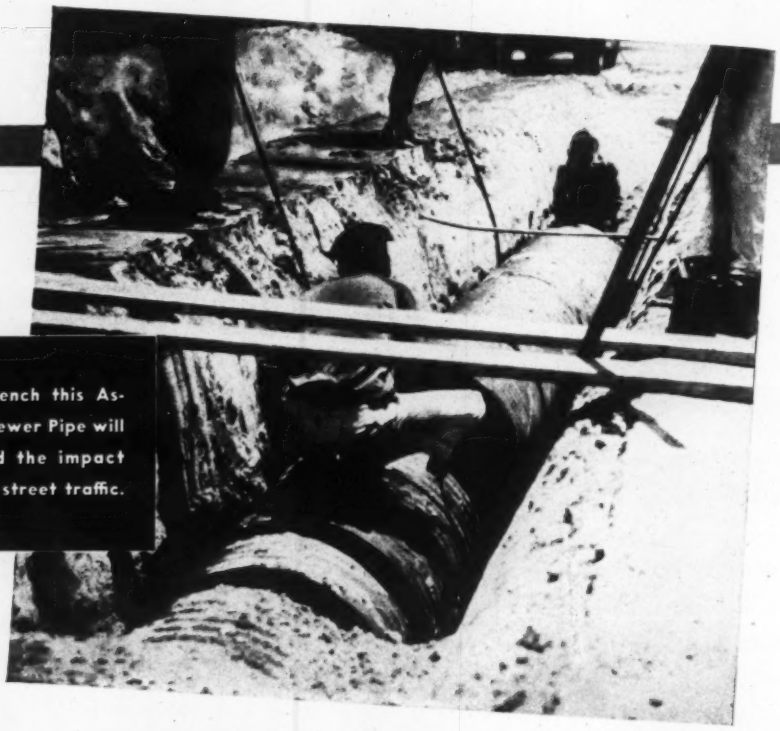

Placed in a shallow trench this Asbestos-Bonded Armco Sewer Pipe will successfully withstand the impact and vibration of heavy street traffic.

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ENGINEERING NEWS-RECORD

Devoted to Buildings, Sewers, Waterworks, Bridges, Highways, Streets, Dams, Foundations, Earthwork, Flood Control, Public Works, Irrigations, Canals, Railroads

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Vol. 123 *August 31, 1939* No. 9

	PAGE
News of the Week	31-86
Reader Comment	37
Editorials	40
Hydraulic Fill Runways for Airport	42
Anchors for Pontoon Bridge	45
Disaster Plans for Flood Emergencies	46
Lean Slag Mix Makes Good Concrete — JOHN K. HARRIS	47
Truck Train Live Loading — WILLIAM E. WILBUR	48
Lighting the Modern Road Tunnel — R. W. SWETLAND	49
Submerged Weir Formula Verified — GLEN N. COX	52
Electric Heat Speeds Curing Of Concrete — H. K. BURCH	53
Simple Arch Roof for Boston Skating Rink — C. M. SPOFFORD	54
A Low Cost Soil Testing Outfit — DONALD M. BURMISTER	56
Continuous Welded Rail Study Begun	58
Precast Spillway-Ditch Lining	59
Should WPA Continue in Construction? Yes—says F. C. HARRINGTON No—says W. A. KLINGER	60
Pressure Aqueduct for Boston — KARL R. KENNISON	63
Making Large Aqueduct Pipe	66
Story of the Boston Broadside — M. N. BAKER	70
Water Storage in a Spheroidal Tank	71
Test Tube Technique in Sewage Reseach — E. J. CLEARY	74
Garbage Digested with Sludge	76
From Field and Office	77
Book Notes and Reviews	78
Contract Unit Prices	82
New Aids to the Constructor	96
Construction Reports	113

THIS WEEK

● The presentation of opposing views on vital questions that confront the construction industry in the conduct of its affairs and in its relationship with business, labor and government is inaugurated in this issue on page 60. The question first presented relates to WPA in construction, upon which every reader, after careful analysis of the pros and cons, should register an opinion. A postage-free mailing card is provided for the purpose. F. C. Harrington and W. A. Klinger give a balance sheet of instructive facts.

● Scientific methods of fill construction now being employed in building the new airport at Washington give promise of eliminating one of the chief problems of past years in building airports on made land, that of settlement of the runways after they have been paved.

● Great improvements in the lighting of vehicle tunnels have been made in recent years. These advances are summarized on p. 49 by R. W. Swetland of the General Electric Co. Increasing use of highway tunnels and the current demand for higher speeds through tunnels gives special significance to the information presented by Mr. Swetland.

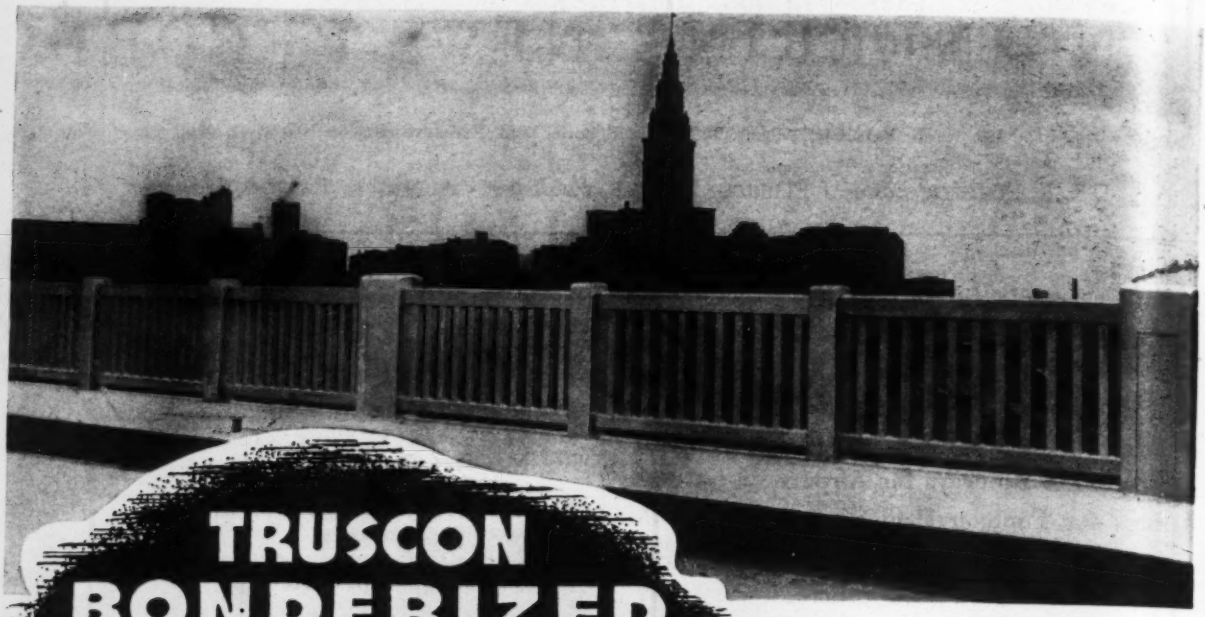
● Boston is improving the quality of its water and the method of distribution by construction of a new pressure aqueduct to supplement the present inadequate ones. One article in the issue describes the aqueduct and a second gives details of methods used in the manufacture of concrete pipe for the aqueduct. These methods are worthy of special note.

THINGS TO COME

WORK is being pushed on Pennsylvania's cross-state toll road, the South Penn Highway. Progress on this 161-mi. undertaking will be reported in the near future.

APPLICATION of scientific methods of fill construction to levee building was tried with good results on some work done last year along the Rio Grande. Details will be given in the Sept. 14 issue.

CANALIZATION of the Tennesee River brought backwater into the town of Guntersville, Ala. How low areas of the city were protected and how its water and sewer services were revamped is to be described Sept. 14.

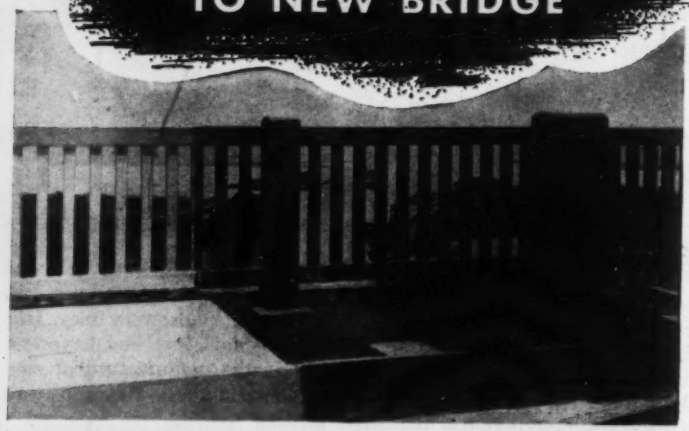


TRUSCON BONDERIZED ALL STEEL RAILING

(WITH BAKED-ON PRIMER)

adds

PROTECTION AND BEAUTY TO NEW BRIDGE



● The Truscon *Bonderized All-Steel* Railing illustrated is an important detail in the construction of the new Main Avenue Bridge which spans more than a mile of river valley at Cleveland, Ohio. • The "close-up" view at the left shows the all-steel posts locked securely to the supporting steel of the bridge super-structure. The concrete-surfaced sidewalk is reinforced with Truscon Sidewalk Grid as illustrated in the same view. • In the photograph below, Truscon Steel Bridge Flooring and Truscon Catwalk Grating are illustrated. • A total of approximately 1645 tons of Truscon Steel products were used in this bridge which was designed and built under the supervision of the Cuyahoga County Engineer located at Cleveland, Ohio. • For further information regarding Truscon Steel engineering construction products, write us at Youngstown, Ohio.

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47 SALES ENGINEERING OFFICES

SUBSIDIARY: REPUBLIC STEEL CORPORATION

ENGINEERING NEWS-RECORD

Volume 123 AUGUST 31, 1939 Number 9

Louisiana University Sues Former Construction Man

Suit for the return of $143,000 in monies improperly received was filed in Baton Rouge, Aug. 23, by Louisiana State University against George Caldwell, former superintendent of construction at the university. Caldwell is under indictment and attachments have been secured against various Caldwell properties.

The amount includes $58,000 paid Caldwell as a 2 per cent commission on building contracts; $58,000 allegedly received by Caldwell as "gifts" from contractors and dealers; and $27,000 paid Caldwell as salary from December, 1933 to June 30, 1939. The contracts were awarded under forged university board minutes, it is claimed.

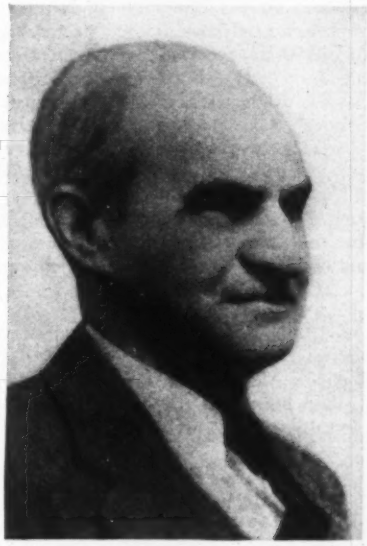
The university's petition alleges that the defendant has acquired extensive properties to a great extent or wholly with money fraudulently obtained from the university and others. The petition was supported by an affidavit from Governor Earl K. Long, ex-officio president of the Board of Supervisors.

• • •

Board Appointed to Study Toronto Disposal Plans

A board of engineers has been appointed to review the reports of Gore & Storrie, Toronto consulting engineers, and Metcalf & Eddy, Boston engineers, in connection with the proposed sewage disposal plant to be built at Toronto, Ont.

Members of the review board are: C. W. Hubbell, president of Hubbell, Roth & Clark, Inc., consulting engineers, Detroit; G. H. Ferguson, chief engineer of the public health engineering division, department of pensions and national health, Ottawa; S. A. Greeley, head of Greeley & Hansen, sanitary engineers, Chicago; W. B. Redfern, partner of James, Proctor & Redfern, consulting engineers, Toronto; and A. E. Derry, director of sanitary engineering, department of public health, Toronto.



GENERAL FERGUSON RETIRES

Brig. Gen. Harley B. Ferguson, division engineer of the lower Mississippi Valley Division and since 1932 president of the Mississippi River Commission, retired from active duty Aug. 14. The current flood-control and channel-improvement program for the lower Mississippi River has been carried out under his direction, including construction of thirteen cutoffs between Arkansas City, Ark., and Natchez, Miss., to shorten the river by 116 miles.

Indiana Utility Plans $6,400,000 Expansion

The Public Service Co. of Indiana is soon to start on a $6,400,000 expansion program, according to Robert A. Gallagher, president.

Plan calls for a 50,000-kw. steam plant at Dresser, Ind., a 132,000-v. substation at New Castle, Ind., and 31 miles of 132,000-v. transmission line.

The work will be financed by the sale of $1,600,000 of common stock and a $4,800,000 bond issue.

PWA Sponsors Warned To Speed Up Work

Work lagging on 67 projects involving $184,000,000 of public construction

In an effort to induce sponsors to speed up work on PWA projects, E. W. Clark, acting commissioner of public works, last week warned sponsors of 67 projects with a total cost of $184,157,000 that work on their projects is lagging. "You cannot expect," he said, "a grant on work done after the June 30, 1940 deadline established by Congress for completion of projects. Grants of $82,639,000 are involved in the 67 projects."

It is probable that similar warnings will soon be issued in connection with other projects on which work is slow. It is already apparent that certain of the largest projects in the program—notably the Chicago subway and the Pennsylvania turnpike—cannot possibly be completed by the deadline. Chicago has already been granted an eighteen-month extension, but none has yet been requested by the turnpike commission.

Last week J. M. Carmody, federal

(*Continued on p.* 33)

• • •

Three Workmen Killed On Baton Rouge Bridge

Three workmen erecting the superstructure of the new Baton Rouge bridge across the Mississippi River fell to their death Aug. 24 when a 1,900 lb. pulley broke loose and smashed the scaffold on which they were standing. Three other men were injured.

The gang was preparing to take down the boom of the derrick which had been used in erecting the steel, and two of them had ridden the block to the bridge deck and back to the top, 150 ft. above the river, when the accident occurred. Five men had previously been killed on the project.

OBITUARY

JOHN J. FISHER, assistant city engineer of Prince Albert, Sask., died Aug. 15. Before coming to Saskatchewan in 1910, he was engaged in the contracting business in Ontario.

CLYDE H. FENTON, office engineer with the Brazos River Conservation and Reclamation District, died recently in Texas. During the past few months he had been in Austin coordinating some of the district's work with the board of water engineers but his permanent office was at Temple.

PAUL A. DIEHL, 45, engineer of Kansas City, Mo., died on Aug. 19 at Altus, Okla., while inspecting a sewage disposal plant. Diehl was making a survey for the city to eliminate obnoxious odors of the system. After graduating in 1919 with B.S. degree from the University of Kansas, Diehl went to work with Black & Veatch, consulting engineers of Kansas City, Mo. For a time he was resident engineer on construction of water works, sewer systems, paving and other improvements. In 1925 he became their western representative in charge of the Los Angeles office.

HIRAM G. ELDER, retired building contractor, died recently at Miami, Fla., at the age of 70. He came to Miami 17 years ago from Burlington, Ia.

GORDON HUFFINES, 37, resident executive engineer at New Bern, N. C., for the Cline Construction Co. of Raleigh, died at New Bern Aug. 25.

RALPH S. HAWLEY, city engineer of Emeryville, Calif., for the past 30 years, died recently at the age of 62. After graduating in 1903 from the college of engineering at the University of California, Hawley accepted a position with the U. S. Geological Survey. With that organization he made surveys in California and Arizona, carrying out hydrographic investigations in the Owens River Valley and for the Yuma reclamation project. Starting in 1907, for one year he worked in the city engineer's office of Oakland, preparing plans for municipal improvements. In 1908 he went to Emeryville as city engineer.

HARRY A. GENUNG, city engineer of Biloxi, Miss., died recently at Gulfport. A civil engineer specializing in railroad construction, he had been employed in various parts of the United States and in Central America. At one time he was maintenance engineer for the Gulf & Ship Island R.R. and was later field engineer on the construction of the $4,000,000 Harrison County seawall.

CHARLES A. CRAVEN, 69, a building contractor in East Cleveland, Ohio, died Aug. 16 in Detroit.

ROBERT L. JAMES, 38, district engineer with the North Carolina state highway commission and located at Rocky Mount, died in an automobile accident near Kinston, N. C., Aug. 20.

GERALD C. L. FOSTER, for the past eight years a member of the engineering staff of the Canadian Department of Interior, Ottawa, Ont., died there Aug. 19. He received his engineering education at Rothesay Collegiate School, Rothesay, N. B., and King's College, then at Windsor, N. S. He served overseas with the Canadian artillery during the World War, returning to Canada to join the engineering staff of the Valley R.R. He later worked for the New Brunswick government and with the Ottawa-Montreal Power Co. at Montreal.

RICHARD PEARSON, 48, Idaho district highway maintenance engineer at Coeur d'Alene, died there Aug. 17. He had been with the highway department 15 years.

CLYDE S. REED, 56, contractor of Asheville, N. C., died Aug. 18. Reed was one of the first concrete bridge builders in western North Carolina, erecting Smith's bridge, Gudger's bridge and other spans in that section of the state. He organized the Asheville Dray, Fuel & Construction Co., which later became known as the Asheville Construction Co.

GEORGE M. HENRY, retired building contractor, died Aug. 18 at Bellefontaine, Ohio. He was 73 years of age.

CHARLES L. PORTER, 60, contractor of Charlotte, N. C., died Aug. 20. Porter early became associated with the civil engineering department of the Southern R.R. where he remained for 15 years. Later, he formed the Porter & Peck General Contracting Co. He retired from active business in 1935.

JOHN A. KINGMAN, retired engineer and former advertising specialist of Yonkers, N. Y., died Aug. 20 at the age of 65. He was a graduate of Rensselaer Polytechnic Institute.

ERNEST DONAT, 75, retired Polish civil engineer, died Aug. 28 in Wallingford, Conn. Born in Poland, Donat came to the United States eight years ago. Previously he had been in charge of large engineering developments in England and Germany.

VICTOR H. FROMLET, 57, civil and structural engineer and former deputy commissioner of the Department of Buildings in Manhattan, New York City, died Aug. 28. Following his graduation from the University of Cincinnati in 1904, he soon became connected with the Roanoke Bridge Co., Roanoke, Va. He was associated for more than 15 years with the Buchman & Kahn, architects, New York City, before joining the building department.

Photo by Allen P. Child

COMBINATION BRIDGE AND CHECK DAM IN ARIZONA

CHECK dam and highway bridge service are provided in the one structure illustrated above. A series of nine such check dams have been built to provide surfaced roadways up a canyon giving access to an artificial lake in the Santa Catalina Mountains about 15 miles from Tucson, Ariz.

Each dam is built of concrete and lined with granite boulders secured from the canyon sides. As can be seen in the picture, the flow is ordinarily conducted through a channel at the right-hand end of the structure, but in times of extreme flow the dam can be overtopped safely. In hot weather the pools formed by the checking of the water may be used for swimming.

Louisiana Authorities Rescind Contracts

Action on $433,000 of work follows instructions from PWA officials in Washington

Contracts totalling $433,000 that have been awarded by Louisiana school authorities to Caldwell Bros. & Hart, New Orleans contractors, have been rescinded, according to an announcement by State Superintendent T. H. Harris. Action was taken upon instructions from the PWA officials in Washington, D. C.

Monte Hart, partner in the firm, is under federal grand jury indictment in New Orleans for using the mails to defraud in connection with the alleged sale of furnishings of the Bienville Hotel to Louisiana State University after a prior conveyance of the entire plant and contents to the university.

The low bid of $172,000 by the Caldwell Bros. & Hart for equipping the laundry and power plant of the Louisiana Polytechnic Institute at Ruston, La., had been accepted and a contract awarded. Later it was rescinded and awarded to C. Wallace Plumbing Co., second low bidder. The $260,000 contract to the Caldwell firm for a natatorium and student center for the Louisiana Normal College at Natchitoches, La., had been awarded pending approval by PWA of changes whereby the two projects were to be in separate structures. This contract was also rescinded and the R. P. Farnsworth Co., New Orleans, given a contract for the work.

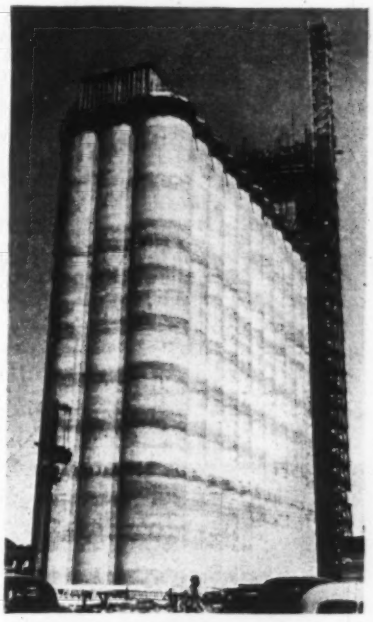
Formal approval of the new contracts have been scheduled for a meeting of the state Board of Education on September 12.

Thirteen equipment contracts totalling $621,000 also have been rescinded by the board of administrators of Charity Hospital at New Orleans. This action, according to Fred W. Matthews, secretary-treasurer, was to conserve the hospital's resources.

• • •

New Jersey Housing Bids Rejected

Bids submitted by private contractors for the construction of low-rent housing projects to be known as the Elizabeth Robinson Village in Asbury Park, N. J., have been rejected as "unreasonably high". Bids for the William Dunlap Homes, a low-rent project at Perth Amboy, N. J., have been rejected by USHA officials for the same reason. Both projects will be re-advertised later for bids.



NEW GRAIN ELEVATOR FOR SPOKANE

AN ELEVATOR to store 454,000 bushels of grain is being completed at Spokane, Wash., by Alloway & Georg, Spokane contractors, for the Centennial Flouring Mills Co. at a cost of $200,000. The bin unit is 45 ft. wide, 186 ft. long and 200 ft. high. The bin unit is part of $1,000,000 flour mill with a daily capacity of 3,000 bushels.

PWA Construction Slow

(Continued from p. 31)

works administrator, said that "We face the possibility—and probability—of a number of recisions of allotments for large projects which seem to have no chance to be completed before the June 30 deadline."

It is regarded as unlikely, however, that such drastic action will be taken in many cases. Congress required only that projects be "substantially" completed, leaving PWA considerable discretion. Any funds obtained by recisions would not, of course, be available for new projects because of the starting date required in the law.

Among the larger of the lagging projects are: municipal building project at Brooklyn, N. Y., estimated cost $2,700,000; Harrisburg, Pa. $2,800,000 water supply development; Chicago's school building program costing $7,000,000; the $5,000,000 disposal plant at Rock Island, Ill.; Cleveland's river improvement work costing $5,400,000; the Mobile, Ala., tunnel project, estimated cost $4,000,000, and the $8,400,000 bridge project in King County, Wash.

FHA Eases Rules On Construction Loans

15-year loans now possible and borrower need not own the building site

In response to a demand from California and the southern states for easier loans on cheaply built houses, the Federal Housing Administration has liberalized its rules on house construction loans made under the modernization loan procedure. Modernization loans are not individually guaranteed by FHA as are FHA-insured construction loans; FHA simply guarantees banks making modernization loans against loss up to 10 per cent of its total loans. In the past, FHA has permitted banks to include 10-year loans at an interest rate amounting to a little more than 6 per cent for construction of small houses; borrowers were required to own the land, but otherwise FHA's usual standards of construction and neighborhood did not apply.

FHA this week extended the term of this type of loan to 15 years and dropped the requirement that the borrower own the land; it will now be required only that the borrower have a 5 per cent equity in the house and land. Under the revised plan, monthly payments on a $2,000 house would be about $17, whereas previously they would have been about $22.

Because of the higher interest rate and shorter term this type of loan is ordinarily less attractive than a regular FHA-insured mortgage (in the example above, payments on the regular plan would be only about $10), but it is felt that it will aid in financing such structures as summer cottages and also provide housing for persons of low income who cannot raise the 10 per cent down payment ordinarily required, cannot afford to build to FHA standards, or wish to build on un-zoned land.

• • •

Missouri WPA Job Vacated by Murray

Matthew S. Murray, WPA administrator in Missouri, asked for and received a leave of absence last week from his position pending the outcome of a federal investigation of his income tax returns. Murray, who had been head of the Kansas City public works department for many years under the Pendergast regime, and held both this job and the WPA job simultaneously, resigned from the Kansas City post some time ago. The state WPA job will be filled by the present assistant administrator, E. M. Basye, formerly an engineer with the Kansas City Southern Ry.

WASHINGTON HIGHLIGHTS

Special reports by Paul Wooton

NEARLY ALL WASHINGTON, D. C., building and construction work involving concrete placing or plumbing installation was at a standstill last week. A week-old strike of employes of the Smoot Sand & Gravel Co., chief local supplier, shut off the flow of concrete aggregate as the company's reserve supplies were exhausted. Early this week about 300 plumbers went on strike seeking a $1 a day increase in the $12 daily rate prevailing since 1929. About a hundred plumbers continued working for contractors who signed temporary agreements granting their demands.

INVESTIGATORS for the Department of Justice preparing for broad anti-trust law violation suits in the building industry, who have been concentrating their attention on collusion among contractors and with labor unions, have now turned to investigation of the activities of building material manufacturers.

PICKETING by the CIO has led the Bureau of Reclamation to use force account instead of Civilian Conservation Corps labor on clean-up work at Boca Dam on the Little Truckee River in California. After the contractor finished work on the dam, the CCC was brought in Aug. 24 but was immediately picketted by the CIO group, which had had a contract on construction of the dam. The CCC was withdrawn the following day and an attempt was made to do the work force account; the union objected to this also, and this was stopped. This week the bureau decided to resume force account work. Under the law, force account workers must be locally certified by the civil service. This was the first time the bureau has tried to use CCC labor for construction on one of its dams, CCC men having done reservoir clearing on this and other projects without objection from union labor.

• • •

North Carolina to Improve State and County Roads

Governor Hoey of North Carolina has allocated $2,000,000 from the state highway fund surplus to be used on state and county roads, $200,000 to be spent on bridges, 60 per cent of the remaining money for improving primary roads and 40 per cent for secondary road improvement.

The new allocation, combined with federal funds and legislative highway appropriation, makes a total of $20,800,000 available in North Carolina for road construction, improvements, maintenance and retreatments during the current fiscal year.

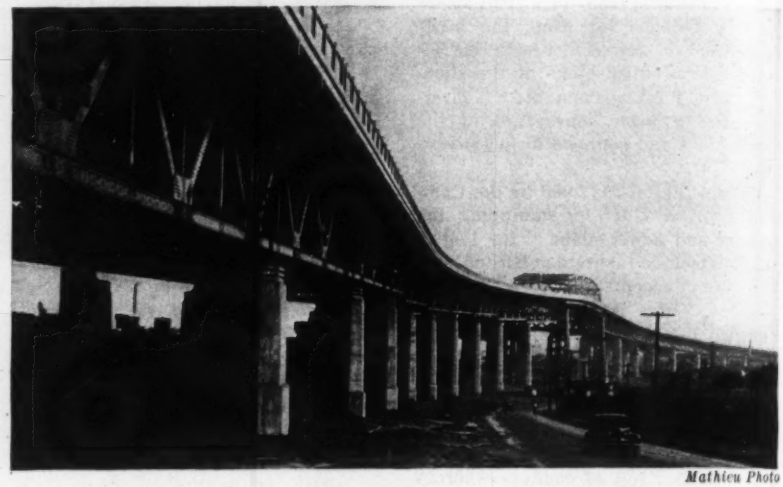
• • •

Elevator Group Accused As Monopoly in New York

Monopolistic practices and illegal use of patents were charged August 23 against 18 elevator manufacturing companies and their membership association in a New York State court proceeding. Twenty-two officers of the defendant companies were cited and the Attorney General has been asked for an injunction to restrain the defendants from continuing the alleged illegal acts.

The defendant companies and their officers through their trade association, the National Elevator Manufacturing Industry, Inc., allegedly charted the volume of business of each member concern from and including the years 1929-33, and agreed not to seek more than their share of new business.

New Express Highway Connects Brooklyn and Queens

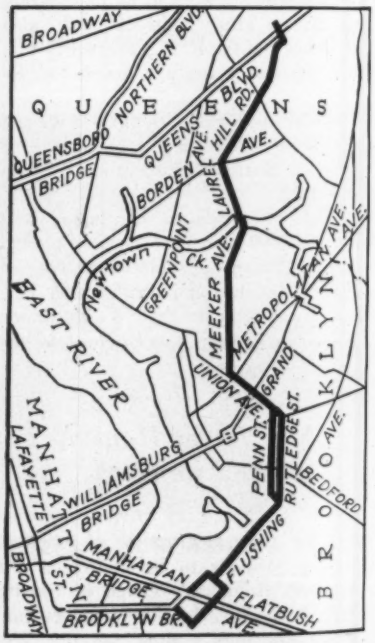


Mathieu Photo

DEDICATION on Aug. 23 of the new Meeker Ave. bridge over Newtown Creek, boundary between the boroughs of Brooklyn and Queens in New York City, opened a 7-mi., 6-lane express highway that has great traffic-relief possibilities. Because the highway ties together the eastern ends of all of the East River bridges, traffic from lower Manhattan can now reach Queens and the Long Island parkway system via the Brooklyn, Manhattan or Williamsburgh bridges instead of traversing the streets of mid-town Manhattan and the over-crowded Queensboro Bridge. Commercial as well as pleasure traffic is accommodated. The new road also taps (at Borden Ave.) the approach to the new Midtown Tunnel now under construction under the East River.

Shown in the accompanying photo is a steel deck viaduct, part of the Meeker Ave. bridge which crosses Newtown Creek on a through span with 125 ft. shipping clearance.

The cost of the Brooklyn-Queens connecting highway, as it is called, is stated to be $10,000,000. It is a product of the New York City department of public works, Irving V. A. Huie, commissioner and Homer R. Seely, deputy commissioner in charge of bridges. Principal contractors were Reiss & Weinsier, Inc.; Chas. F. Vachris; Elmhurst Contracting Co.; American Bridge Co., and Corbetta Construction Co.



Aircraft Plant to Add Large Working Space

Grumman Aircraft Corp. has signed construction contracts to increase the manufacturing space of its plant at Bethpage, L. I., by more than fifty per cent, according to L. R. Grumman, president. Work under direction of The Austin Company, engineers and builders, will begin Sept. 1 and will be completed by Dec. 15.

The contracts call for design and erection of a 48,000 sq.ft. addition at a cost of $150,000, giving Grumman about 150,000 sq. ft. of plant space for manufacture of amphibian and fighting planes. The company's assembly line will be 640 ft. long and 100 ft. wide.

The expansion program will provide an addition 140 by 240 ft. to the main manufacturing plant, a wing 100 ft. by 140 ft. and substantial additions to the research and experimental department and boiler room. A concrete apron 140 ft. square is also included.

• • •

Excessive Bidding Claimed In Pittsburgh PWA Work

Excessive bidding has marked the award of more than $1,000,000 worth of city PWA contracts during the past two years in Pittsburgh, according to Budget Controller Richard Neff, following three months of investigation. Evidence gathered has been forwarded to Washington and the Pittsburgh council has requested that Attorney-General Murphy, the PWA offices and the Federal Trade Commission investigate bids on the work for trace of collusion. Last week the city council adopted a resolution asking the Attorney-General to give priority to the Pittsburgh situation.

Low cost housing, hospitalization and city recreation projects are questioned. The bids questioned are confined to those for the plumbing, heating and electrical work.

Federal investigators checking the Pittsburgh situation have declined to comment upon their findings. They represent PWA and the anti-trust division of the Department of Justice.

• • •

Unions Win Closed Shop On Green Mountain Dam

Last week representatives of the Warner Construction Co. and AFL officials signed an agreement, whereby only union workmen will be employed at the Green Mountain Dam work, a $4,000,000 Bureau of Reclamation project which is part of the Colorado-Big Thompson irrigation and power development in Colorado. The agreement provides that employees on the project must join the union within seven days after starting work.

Over 300 workmen who walked off the job in July will be reinstated. Preference is to be shown to residents of the Northern Colorado Conservancy District which is paying part of the cost of the work.

Two hundred members of the national guard of Colorado who were sent to the area when six men were injured in labor disorders Aug. 3 (see *ENR*, Aug. 10, 1939, p. 179), will remain in the area until the agreement takes effect.

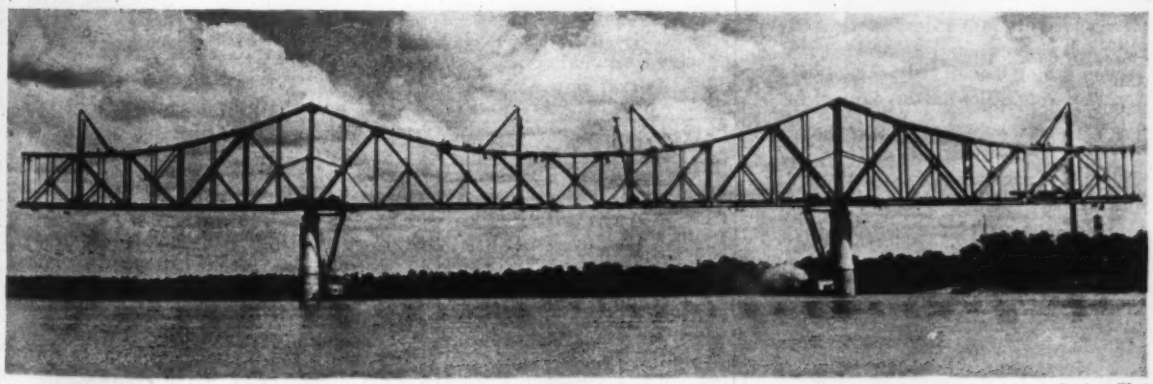
Engineers Cancel New York Meeting

International Engineering Congress cancelled due to inability of British engineers to attend

The British-American Engineering Congress, scheduled to be held in New York Sept. 5-8 was cancelled on Aug. 25 when word was received from the British delegation that the threat of war in Europe made it impossible for its members to leave England. The congress was to be sponsored jointly by Institution of Civil Engineers and the Institution of Mechanical Engineers of Great Britain, the Engineering Institute of Canada, the American Society of Civil Engineers and the American Society of Mechanical Engineers.

New York had been selected as the place of meeting to permit the delegates to see the New York World's Fair and part of the social program was to have taken place there. Technical sessions were to have been held at the Engineering Societies Building in New York and at Columbia University. No decision has been announced as to what disposition is to be made of the papers prepared for the Congress.

The Am. Soc. C.E. will hold no fall meeting. The fall meeting of its board of direction which was scheduled to be held in advance of the congress has been postponed but will be held some time before Oct. 15, the limiting date set in the constitution for the board to meet as a nominating committee to select a candidate for president for the ensuing year.



Central Photo

WORK ADVANCES ON BATON ROUGE BRIDGE

LOOKING upstream at the central anchor span, of the combined highway and railway bridge being built across the Mississippi just above Baton Rouge. The central span is 650 ft. long, and the two adjoining channel spans will be 588 ft. There will also be two shore anchor spans of 490 ft. Steelwork shown was erected by balancing about the piers, falsework being impracticable because of the water depth.

The bridge is being built by the Louisiana Highway Commission. Harrington and Cortelyou, Kansas City, Mo., are the consulting engineers. Contract for the steelwork is held by the Bethlehem Steel Co., Kansas City Bridge Co. built the main river piers; Uvalde Construction Co. constructed the approach foundations and the Steel Construction Co. built the approach superstructure. H. B. Henderlite is chief engineer for the commission. N. E. Lant is bridge engineer and E. L. Erickson, construction engineer at the bridge. Cost of the work is $8,500,000.

Texas Turns Down Plans for Free Bridge at Laredo

According to announcements recently made by officials of the Texas state highway department, plans for the construction of a new and free international bridge between Laredo, Texas, and Nuevo Laredo, Mexico, are definitely dead for at least two years and probably longer. It was explained that this delay was due to the failure of the Texas legislature to pass the proper enabling bill during its last session. Plans for this bridge have been approved (as announced in our news pages July 20) by the Mexican Ministry of Communications and Public Works.

Although Mexican government engineers have long claimed that the present toll bridge was inadequate, it has been given a clean bill of health recently by traffic engineers employed by the Texas state highway department. The report issued by these engineers declares that the present bridge is adequate for present and future traffic, and that all that is needed in order to obviate congestion is to provide terminal enlargements and improvements for governmental inspection services at both ends of the bridge. Plans for work at the American end are under way.

Announcements have also been made by the collector of customs representing the federal government that plans were proceeding for the construction of a new building for the governmental inspection services at the American end of the bridge. This improvement will follow the suggestions made for terminal improvements and will make the American end of the present bridge adequate for present and future needs. Final purchase of land for the new government building will be completed within a few weeks, and plans for construction will follow shortly. The total federal appropriation for this project is $290,000.

• • •

Nebraska Housing Law Held Constitutional

Constitutionality of the Nebraska state housing law has been upheld in a state district court, question of its legality having been raised in connection with the Logan Fontenelle Homes in Omaha.

The project was completed by the federal government and turned over to the local housing authority for operation. A question arose over the question of its control and Kelso Morgan and Byron Burbank, attorneys representing the dissatisfied citizens, started suit.

Attorney Phillip Klutznick representing the Housing Authority argued Congress appropriated monies for Omaha's and similar projects throughout the country to give good housing to families in the low income brackets. He says that there was a shortage of sanitary homes available at rents those people could afford to pay.

• • •

Brooklyn Bridge Rebuilding Unrelated to Battery Span

Studies for rebuilding Brooklyn Bridge, as reported in last week's issue, p. 243, were begun in 1934. The present recommendation of the New York City department of public works to the department of city planning that funds for the start of work be included in the 1940 capital budget is unrelated to the War Department's refusal to approve the projected Battery Bridge, as was implied by the comment in our summary of the news of the week. The studies show that the Brooklyn Bridge serves a definite traffic load that will be little affected by the construction of either a bridge or tunnel at the Battery and that, to meet the growth in that load, reconstruction of the deck to increase its capacity is necessary.

CONTRACTS AND CAPITAL

ENGINEERING construction awards for the week, $67,009,000, are 9 per cent above a week ago, and 28 per cent above the volume for the 1938 week.

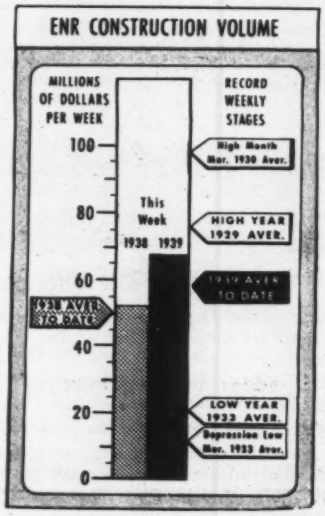
The current week's awards bring the 1939 construction volume to $2,049,915,000, an increase of 16.3 per cent over the $1,762,254,000 reported for the initial 35-week period last year.

Private construction for the week is 165 per cent higher than in the 1938 week, but is 14 per cent below last week. Public awards are 1 per cent below a year ago, but top a week ago by 29 per cent.

Unclassified construction awards reached the highest weekly level since July 8, 1937, due to the $15,000,000 contract for the construction of a 240-mile gas pipe line in Iowa and Minnesota by the Northern Natural Gas Company. In addition to unclassified construction, waterworks, commercial buildings and large-scale private housing, and earthwork and drainage report gains over a year ago; and sewerage, bridges, industrial buildings, public buildings, earthwork and drainage, and streets and roads exceed their respective totals of a week ago.

New capital for construction purposes for the week, $12,199,000, is 72 per cent lower than in the corresponding 1938 week. The current week's new financing is made up of $10,072,000 in corporate security issues, and $2,127,000 in state and municipal bonds.

New construction financing for the year to date, $2,149,740,000, is 23 per cent below the 1938 figure.



CONTRACTS

(Thousands of dollars)

	Week Ending Sept. 1 1938	Aug. 24 1939	Aug. 31 1939
Federal	$8,686	$3,702	$12,990
State & Municipal	34,372	29,500	29,791
Total public	$43,058	$33,202	$42,781
Total private	9,161	28,248*	24,228
TOTALS	$52,219	$61,450*	$67,009
Cumulative 1939 (35 weeks)			$2,049,915
1938 (35 weeks)			$1,762,254

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

* Revised.

NEW PRODUCTIVE CAPITAL

	Cumulative 1938 35 Wk.	1939 35 Wk.
NON-FEDERAL	$1,638,579	$1,021,712
Corp. securities	271,215	173,578
State & Mun.	392,273	403,982
R.E.A. loans	11,029	89,445
R.F.C. loans	96,891	3,853
P.W.A. allot.	510,543	.....
U.S.H.A. loans	154,528	160,852
Fed. Aid—Hwys.	201,500	190,000
FEDERAL	$1,143,942	$1,128,028
TOTAL CAPITAL	$2,782,521	$2,149,740

FHA MORTGAGES

	Week Ending Aug. 27 1938	Aug. 19 1939	Aug. 26 1939
Selected for appraisal	$23,367	$23,689	$21,798*
Cumulative 1939 (34 weeks)			$766,387*
1938 (35 weeks)			$647,340

* Subject to revision.

ENR INDEX NUMBERS

Index Base		1913	1926
Construction Cost	Aug.	234.90	112.92
Building Cost	Aug.	196.54	106.24
Volume	July	166	73

COMMENT AND DISCUSSION

Readers' opinions on matters that concern the engineer

Chicago Plan Commission

Sir: In the Aug. 10 issue of *Engineering News-Record* I noticed the little item on page 7 about the new Chicago Plan Commission ordinance. There were two errors in the item, there being only 22 members in the new commission, 10 of whom are civilians appointed by the mayor and 12 members ex-officio.

ROBERT KINGERY
General Manager
Chicago Regional Plan Association

The Mississippi's Future

Sir: An article entitled "Mississippi River Cut-Offs Effective" in your issue of Aug. 3 gives an interesting account of the work accomplished during the past six years tending to shorten the Mississippi River and to increase its effective cross-sectional area, thus reducing flood stages for comparable discharges. The results attained are most gratifying and should be a source of comfort and encouragement to the people of the Lower Mississippi Valley. The initiative and perseverance demonstrated in combating the many difficulties and obstacles encountered should be duly recognized and favorably commented on, as you have done.

Some of the conclusions affirmed by the writer of the article, however, appear to lack substantiation and to have been reached prematurely. Let us not suddenly assume, before the work undertaken is fully completed, that, because "cutoffs are effective," the "control of the lower Mississippi River is virtually an accomplished fact." The river is undoubtedly "safer and more stable" now than it was six years ago, but to extend that characteristic to the future behavior of the river is unsound and not presently justified. It has by no means been demonstrated that other works of importance, such as the Tensas River floodway, are no longer needed and would not be used if built. Indeed, the "evolution of the work was a trial-and-error process"; in fact, the whole process is still in the experimental stage. The past has proved that the river has its own way of mobilizing, sometimes taking years to prepare for a sudden onslaught, at highest flood stages. The river has apparently been disciplined, but has it been conquered? Is the transformation of the river "from the uncontrolled condition in which it existed since the white man first saw it" complete, final, and permanent? No acceptable proof has been submitted and only time will tell.

Many questions come to mind in reading your article. For instance, what has become of the 500 million cubic yards dredged from the upper reaches? Has it all gone to the Gulf; has it been reasonably distributed in the lower reaches, or has the river deposited it in some unobserved part of its channel in large blocks where some force is already at work generating future trouble?

Have there been any calculations made to estimate the effect of shortening the river by one-third of its length at Old River in times of great synchronous floods of the proportions of the 1927 flood?

Your article may lull the inhabitants of the Lower Valley into the feeling that "finis" can be written after the words "Flood Control of the Mississippi River" and that continued security for them involves no further expenditure of effort and money on the Mississippi.

That sense of security would be tragic. The suggestion is regrettable and does an injustice to the people of the Valley below Cairo.

Much work lies ahead and funds must be made available for a continued struggle with the river until all doubts as to its controlled condition are removed. The Mississippi River is not as yet under such control that we can turn our attention aside.

MARCEL GARSAUD
Consulting Engineer,
Jersey City, N. J.

Our article was not intended to say or imply that watchful care of the Mississippi can be dispensed with in future. Expenditure of effort and money to maintain the river will of course have to continue. Its channel has been made more efficient, and such a channel should be easier to maintain, but it cannot be self-maintaining. The maintenance problem will be further modified as more reservoirs are built on the tributaries; their effect on the channel, like that of the present river changes, will no doubt have to await the demonstration of experience.

Mr. Garsaud implies that the more efficient channel, by increasing the river's residual energy, may give rise to danger in great synchronous floods. Since hydraulic experience indicates that flow is destructive in proportion to its energy wastes rather than its total energy, it may fairly be inferred that so long as due care is exercised the future flood hazards will not necessarily be greater than those existing before the channel changes.

Unquestionably, an undue sense of security would be tragic, as Mr. Garsaud says. Undue apprehension may be almost as tragic.—EDITOR

Underwater Foundations

Sir: The head on the article on page 67 of the Aug. 3 issue, "Cofferdam Sealed in a Novel Way," is far more truthful than the beginning of the first sentence—"The old but ever interesting problem of constructing underwater foundations in the dry on rock, with a thin cover of soil . . ." The casual reader might easily draw the conclusion that the only novelty was the method employed, while to my knowledge I would say, considering the infrequency in which cofferdams are sealed to solid rock and worked "in the dry," that the idea as well as the method employed is novel and unusual.

The building of this foundation in the manner described deserves more than a hurried reading. Looking at the drawings, it appears very simple—almost a routine procedure—but I cannot believe that the selection was made in such a casual way. The method selected must have been weighed against other methods, possibly the pneumatic caisson, which is much more conservative and expensive in proportion. The question regarding the possibility of seams in the rock of sufficient size to emit quantities of water too large to be taken care of with pumps; also the

problem of sealing them off in order to place the base concrete properly; the question of being certain that a good seal would be obtained between the underwater concrete and the rock; the question of what the contractor would have to do provided, for some cause, he could not pump out the cofferdam, and numerous other questions must have been carefully considered and weighed before the final decision was reached.

Contractors as a rule are very loath to employ divers except on work which, in their mind, cannot be done any other way—a sort of a last resort. In foundation work, in my opinion, work by divers is not being given the consideration it deserves, and it is encouraging to see that in the planning for the construction of this pier, no such feeling existed.

Personally, the successful execution of the pier as described, is very interesting to me, as the method used by C. W. Blakeslee & Sons was very seriously considered by our company in our study for the construction of the south Main Pier of the Lions Gate Bridge (*ENR*, Feb. 16, 1939, p. 209). The two pier sites are quite similar except that we did not have any cover on the rock. In our case, the compromise design allowed us to seal the caisson to the rock, but at the same time we had invested considerable money in a convertible caisson for the contingency of not not being able to get a seal, in which case we would convert to a pneumatic caisson. The justification of such an expenditure is purely a question of one's faith in underwater concrete, and a knowledge of the rock to which you desire to make the seal.

W. F. Way
Vice-President,
Stuart Cameron & Co., Ltd.
Vancouver, B. C.

Cracking Walls

Sir: A few random thoughts that come to mind in reading Mr. Seelye's article "Achieving Low Cost in Low Cost Housing", (*ENR*, July 2, p. 78). No doubt his diagnosis of causes for the evils mentioned is substantially correct, and his cure for those evils will help, but I very much doubt if they will effect a complete cure.

The portion of the article that interested me particularly was that dealing with the behavior of the bearing walls. My experience leads me to believe that the major cause of the troubles noted is due to expansion of the roof slab, and if the slab is not insulated there is nothing that will prevent this expansion. These troubles occur frequently with the type of building described—concrete floor slabs resting on non-integral bearing walls, but I have never heard of any of these wall troubles occurring in a regular skeleton frame type of building. This is easy to understand, while, of course, the same expansion takes place, the walls being supported on the frame naturally work back and forth with the frame and any cracks are small and not noticeable.

I had an experience with a building that started to give trouble due to expansion of roof slab. This was indicated by the binding of certain doors on the upper floor along in the afternoon of warm days. Instrument observations indicated an overhang at exposed end of building of ⅝ in. between roof and top floor (no noticeable overhang on lower floors) between early morning and mid-afternoon. However, there was nothing to indicate this in the brickwork.

There also is no questioning the fact that the skeleton frame type can be built for less money than the bearing-wall type—at least in this section of the country. The comparatively small increase in quantity of material in the frame is much more than offset by the many economies of construction, not the least being the possibility of keeping the several construction crews together continuously until each part of the work is completed.

J. H. Stevenson
Seattle, Wash.

Dated Coordinates

Sir: I was much interested in reading in your issue of June 22, 1939, the article by Prof. Philip Kissam on "Dated Plane Coordinates Needed for Land Surveys." Prof. Kissam states that with the extension of additional control surveys there will be an ever-recurring need for readjustments in order to furnish the local engineers and others with the most probable positions for their local use. He therefore suggests that the coordinates be dated for each new adjustment in order that engineers in the future may easily determine to which set of coordinates any particular survey applies.

Experience in the conduct of control surveys by the Coast and Geodetic Survey does not indicate that there will be need for future extensive readjustments of the control nets of the United States. Undoubtedly there will be need from time to time for readjustments of small areas to meet peculiar conditions, as for instance, where actual earth movements are known to have taken place such as those caused by earthquakes, etc., or where increased property values in certain areas make it necessary to retriangulate with specifications providing for a higher degree of accuracy.

It is true that the situation with regard to the horizontal control net in northern New Jersey and around New York City was such that a readjustment of a small section of the national net was required recently in order to coordinate properly all of the surveys in that region. This has now been accomplished, and it is believed that subsequent surveys in northern New Jersey, supplemental or otherwise, of acceptable accuracy can be adjusted into the net without further change.

The basic horizontal control net of the United States, consisting of first and second-order triangulation, is now adjusted into a rigid system known as the North American Datum of 1927 and there is no reason to believe that there will be any cause for upsetting this adjustment except in small areas for the two causes enumerated above. The national net now consists of some 75,000 miles of triangulation distributed over the United States, and since this is by no means adequate for mapping, engineering, scientific and other purposes, it will be necessary to extend a great deal of additional triangulation into the open areas. This new triangulation will be adjusted into the fixed loops as soon as possible after the field work is completed and should then remain fixed indefinitely.

It should be noted that the second-order triangulation which is used to fill in between the first-order arcs has been greatly increased in accuracy during recent years. Such work now closely approaches the precision of first-order triangulation but the cost has not been increased. The specifications for this work are the same as for first-order triangulation except that triangle closures are allowed to

reach 5 seconds and there is no specific limit on the average closure. The conditions of observations make certain, however, that the average closure will not exceed about 1.5 seconds. With this limit, it is reasonably certain that specifications for second-order triangulation circuit closures may be increased from 1 in 10,000 to 1 in 15,000 or better. In this connection it should be remembered that this circuit closure is the lower limit. The average closure is much better.

The vertical control net of first and second-order leveling now comprises more than 270,000 miles of level lines and about 150,000 benchmarks. It is now based on the 1929 sea-level adjustment, and there is no reason to suppose that changes in this datum will be required except in special cases similar to those noted above pertaining to the triangulation.

It is true that many preliminary adjustments of both the horizontal and vertical control nets have been necessary in the past. As is obvious to most engineers, these were required because in a large territory like the United States where the work has been in progress for more than a hundred years, the data issued from time to time for general use must be of the best possible accuracy and be consistent throughout.

The vital thing required to avoid the very confusing situation which has been anticipated by Prof Kissam is that all control be properly coordinated with all of the work within a reasonable distance of any project. The chief concern of those charged with the responsibility of adjusting the surveys should be that nearby points, included in separate surveys, should always be tied together. When proper coordination is thus obtained, the mathematician has before him the necessary data by which the entire survey can be adjusted into a single unit.

When nearby points are determined from different surveys, sooner or later some local engineer will naturally make a connection between two of them. If the distance is greatly different from that given by the geographic coordinates or inverse computation, he is naturally puzzled by the large discrepancy. If an adjustment of the work has already been made, then some readjustment of these points and the neighboring points becomes necessary. Proper coordination at the start would avoid all of this confusion and the computations would be simpler and less expensive.

It does not seem that there is serious need for dated coordinates, and in any case the dates carried on court and other records would be sufficient for identification.

C. L. GARNER
Chief, Division of Geodesy
U. S. Coast and Geodetic Survey
Washington, D. C.

More on Coordinates

Sir: With respect particularly to the wide recognition now being given to the state plane coordinate systems and the wide benefits to be derived from their ultimate adoption by most of the states, it is felt that a reply should be made to the article by Philip Kissam on dated plane coordinates appearing in the June 22, 1939 issue of *Engineering News-Record*.

Again it is hardly necessary to refer to the advantages of basing all surveys on a common horizontal datum except to emphasize such advantages. However, the same advantages are necessarily limited to the accuracy of the control and to the accuracy of the measurements made in traverse and properly tied to such control.

We, speaking for other local engineers as well as myself, have looked upon the 1927 Datum resulting from the adjustment by the Coast and Geodetic Survey of the triangulation in the western half of the United States as the fundamental control to which the article refers. If by the word "development" as used any changes in position of any station in this valuable network or in the supplementary control is contemplated—even remotely—such development at this time should be viewed with alarm.

With respect to such local control systems as may have been in existence for a number of years and used as a reference in boundary descriptions it is difficult to imagine that any system could have been so used without having some official status such as would be accorded upon official adoption by a governing body. Otherwise the coordinates appearing in a description would have little meaning. Reference in a description to the officially adopted local system in itself dates the coordinates used and no further dating is required.

In discussion of proposal No. 1 of the article, it is difficult to envision what practical end can be obtained by computing preliminary or temporary coordinates for the positions of stations in a new control system or in a system being re-adjusted to fit a more accurate base.

With respect to proposal No. 2, again it is apparent that reference in a description to the officially adopted system upon which the coordinates in the description are based is sufficient identification and that further dating is not required.

The reference in proposal No. 3 to previous coordinates contains the implication that they have become matters of record. It cannot be presumed that the recording of such positions will disappear, so again it is essential for these positions to have been referred to some official system in order to have meaning.

The equations to be developed for the relation of points in an old control system to those in a new one, referred to in proposal No. 4, are, of course, recognized as an expression of the relationship between the systems themselves and reference to the system under which a position has been established is sufficient identification for the position itself.

That all maps, plans and property descriptions should contain only one system of coordinates is the ideal toward which the surveying profession is headed and this ideal will be realized upon the adoption and use of the state systems of plane coordinates for these purposes. But can one say consistently that one uniform system has been realized and at the same time recommend the dating of coordinates which are obviously not in one system?

It is believed that the conveyancing of land and the writing and recording of descriptions of boundaries should not be made subject to any further hazards than now exist. Descriptions wisely written without the advantages of coordinate references may safely avoid future litigation. It would seem best not to attempt to accelerate the use of coordinates in descriptions beyond the normal expansion to be expected in the adoption of survey control.

JOSEPH H. FREEMAN
San Gabriel, Calif.

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AUGUST 31, 1939

CANCELLATION of the British-American Engineering Congress that was to have been held in New York Sept. 5-8 is a regretable result of the war tension that has Europe in its grip and is disturbing the whole world. The date of sailing for the British engineers came last week when war seemed unavoidable. They cabled that they were not coming. Canadian engineers could not say with any confidence that they would come. Therefore, those in charge of the meeting arrangements decided that the only course was to cancel the whole affair. No effective meeting could be held under such conditions. The present hope is that when the war clouds clear it may be possible to plan a new and more comprehensive meeting. Opportunities for engineers from many lands to get together are all too infrequent.

Better Water for Boston

A LONG STEP toward making the excellent Quabbin Aqueduct water fully available to the Boston metropolitan district was taken when it was decided to build the noteworthy tunnel-and-pipe connecting aqueduct from Wachusett to the west border of the district. The old connecting lines restricted the flow and polluted the quality of the water, while the new aqueduct provides for full supply, secure against accident and free from contamination. The pressure-line construction introduces large concrete pressure pipe into eastern practice for the first time, and the elaborate manufacturing plant built to produce the pipe illustrates the readiness with which this relatively new element of construction can be adapted to any location.

A Wrong Righted

CONGRESS in the closing days of its recently ended session scrapped an ancient fetish by discarding the rule that when navigation improvements call for new bridges over waterways the owners shall bear the cost. Hereafter only the cost of work beneficial to the bridge owners is to be assessed against them. Railroads were the chief sufferers under the old rule, and bitterness was added to the pill by the fact that the new waterway generally was designed to take business from them. There never was real justification for the old rule other than maintenance of the sacredness of waterway navigation, and in recent years its inequity has been made all too obvious by the financial plight of the railroads. Congress is to be congratulated on having rectified the old error despite the opposition of navigation interests.

Tunnel Lighting

ROAD TUNNEL LIGHTING presents more than an occasional problem to the highway engineer, and it is certain to recur even more frequently in the future. Improvement in tunneling methods and machinery has largely removed tunnel construction as an obstacle to be feared in highway planning. Entrance roads to cities are commonly best secured by subway or tunnel, and the economics of mountain road location call for increasing numbers of tunnels. The grade-separation underpass is little less than a tunnel in many instances. The emphasis given to tunnel lighting in a following article therefore has immediate value. Three vital requirements are pointed out: (1) Former illumination intensities do not meet the fast and dense traffic needs of the present; (2) adequate lighting calls for a tunnel designed for lighting; and (3) transition lighting at tunnel entrances is needed to ease the strain of changing from bright daylight to the interior illumination.

Safeguard Against Disaster

VALUABLE GUIDANCE to safer building is provided in the new Pacific Coast building code, briefly reviewed in our Book Notes this week. The code stands apart from other building ordinances because the motivating force in its preparation was the need for comprehensive provision against earthquakes. Extensive experience with earthquake damage has been available to the coast engineers, and the results of their analyses of the effects in terms of structural strength are here recorded and made available in terms of practical rules for building. The code makes it clear that the scope and range of building need not be restricted by earthquake considerations, since both large buildings and high buildings can be constructed safely if due strength and elastic resistance are assured by the designer. Yet, as the Santa Barbara and

Long Beach catastrophes made evident, the need for earthquake-safe building is greatest in the field of smaller structures—houses, schools and stores—and it is here that the new code can find its most beneficent application.

For Better Opinions

MORE AND MORE the important questions of the day tend to be concerned with technical matters. As the world moves farther from a horse-and-buggy economy toward one in which mechanization is dominant the opinions which determine policy in business and government become technical opinions. They may be voiced by economists, bankers, lawyers, business men or professional politicians, but they are influenced by engineering considerations and have engineering consequences. It is problematical whether these consequences are always weighed properly, whether the policies benefit from informed technical thought and analysis; in short, whether technical men, engineers and constructors among them, influence our present economy to the degree that is desirable.

The technical man is congenitally inarticulate. Yet technical men as a group have become a vital opinion-forming element in the world of today. These divergent conditions need to be reconciled, and an appreciable start can be made if the same sound reasoning that is used on technical problems is applied to the broader economic questions upon which the engineer's opinion would be useful.

In this issue is inaugurated a plan to stimulate the formation of more and better opinions and to make these opinions articulate. It involves the presentation of opposing views on industry and national questions by recognized authorities who, writing in sober, fair and factual language, give the reader a balance-sheet of facts on which to base his own thinking. In this initial appearance of the forum one of the most important questions of the day is considered, namely, Should WPA Continue in Construction? The two contributors, F. C. Harrington and W. A. Klinger, present opposing arguments that stem from their own wide experience and careful study.

The unemployment relief problem is of vital concern to the nation and the construction industry alike. The question whether it can or should be solved by WPA construction work is one upon which every engineer and construction man should register an opinion, and the forum includes a return mailing card for this purpose. Publication of the results and their release to newspapers and others can give the views effective circulation and influence.

Construction is facing an increasing number of similarly important problems in its relationships with government, with labor, and with business. To an increasing extent the careers of the readers of this journal, their prosperity and opportunities for work, are dependent upon the successful solution of these problems. From a broader national viewpoint, if our industrial economy is to succeed there must be mutual help and understanding between the technical man whose activities make our modern world and the larger group whose political and economic powers shape our destinies. The discussion beginning on page 60, together with the plan to sound out technical opinion, is designed to promote such understanding.

A Battle Won

PURCHASE of the Tennessee Electric Power Co. properties by the Tennessee Valley Authority at a price sufficiently near the book value to be acceptable to the owners under the inequitable conditions in which they were required to bargain calls attention to some of the few benefits that came from the public airing of Arthur Morgan's charges against his fellow directors. The decision of the TVA to make a definite offer to buy the Tennessee Electric properties appears to be one of them. Morgan had long held that the TVA should not enter into destructive competition through the construction of duplicate facilities, at least not until after the local utilities had been given an opporunity to sell at a fair price. But he got nowhere until the spotlight was turned on the TVA.

Similarly, though the TVA act required the directors to determine and publish their allocations of the cost of multiple-use facilities between power, navigation and flood control, no such allocations were made until after the TVA investigation got under way. And then the allocations were found to agree closely with Arthur Morgan's expressed views that power should bear a large share of the cost rather than be treated as a by-product of navigation and flood control.

This event alone, if it results in establishing such an equitable allocation of joint costs as a national policy, which seems at least probable, might repay a man of Morgan's ideals for the disgraceful treatment that he received. It means that he won his battle, though he sacrificed himself.

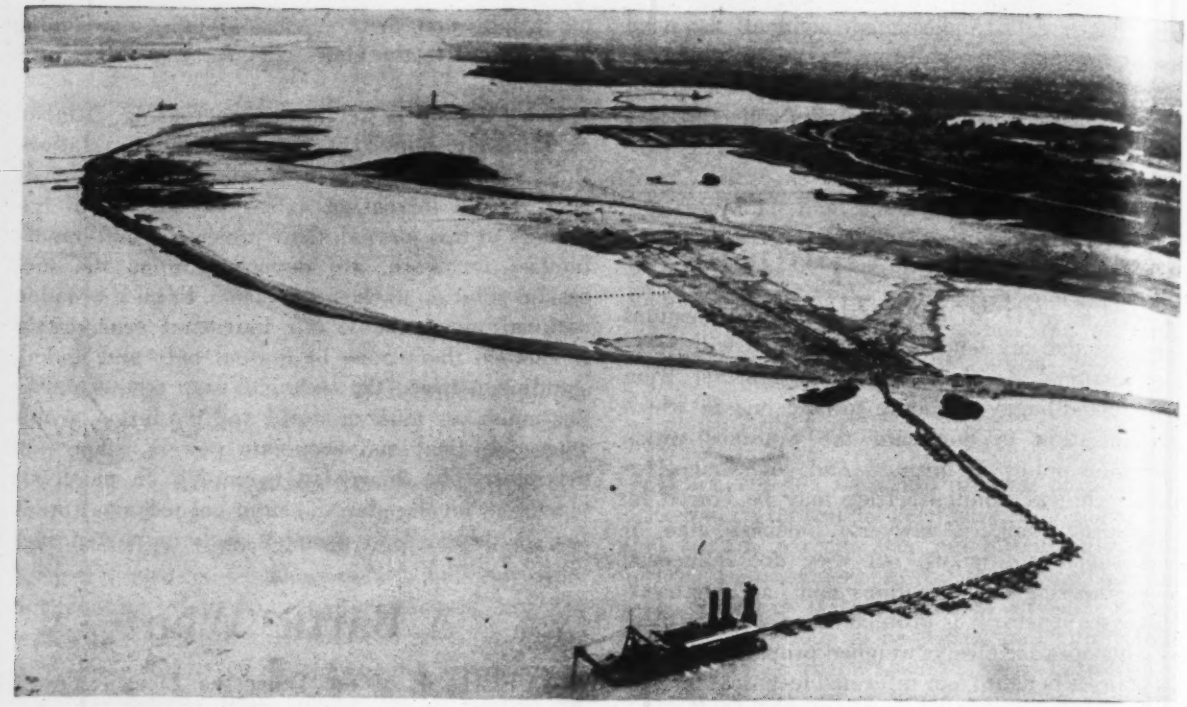


FIG. I. WASHINGTON'S AIRPORT TAKES FORM AS SELECTED HYDRAULIC FILL IS PUMPED INSIDE THE LEVEES.

Hydraulic Fill Runways For Swampland Airport

Contents in Brief—Scientific hydraulic filling is being employed to give the nation's capital adequate modern air-transport facilities within a few minutes drive from the center of Washington on the Virginia side of the Potomac. At runway locations the muck is dredged down to firm material, and the trenches are backfilled with selected sand and gravel pumped in from the nearby river by four large dredges. Placement of runway fill is controlled to squeeze out undesirable fines.

FOUR BIG HYDRAULIC DREDGES are pumping some 15,000,000 cu.yd. of material into the landing field area of the new Washington National Airport at Gravelly Point on the west shore of the Potomac River to create one of the largest and finest airports in the country. Although the site was originally a tidal swampland, the runways will be as unyielding as those on natural ground, for they are being built up of clean sand and gravel pumped into long trenches from which most of the muck has been removed in a scientific hydraulic-fill operation. Through careful control of filling, muck remaining below the trench bottom is either consolidated to firm bearing or squeezed out of the runway location, as are also the undesirable fines pumped in by the dredges. Hydraulic fill unsuited to runways is placed in inter-runway areas.

The new $10,000,000 airport, located on the Virginia side of the river opposite the mouth of the Anacostia River, will be within 15 minutes' drive from the heart of Washington and will replace the inadequate present facilities a short distance upstream. Of a total of 742 acres occupied by the entire airport, 491 acres will be landing field, including 325 acres formerly covered by water at high tide. Landing facilities include a main north-south runway 6,875 ft. long, a northwest-southeast runway, 5,300 ft. long, both to have a 200-ft. paved surface on a solid fill 220 ft. wide with 140-ft. gravel shoulders on each side; and two narrower runways in northeast-southwest and east-west directions 4,820 and 4,200 ft. long, respectively, with 150-ft. paving on 170-ft.-wide fills flanked by 165-ft. shoulders. Numerous paved taxiways, aggregating 11,000 lin. ft., will connect the various runways with the central terminal station. The terminal building will be out in the open providing a full view of all runways; hangars, administration and other service buildings will be back from the landing field. This will necessitate relocation of about a mile of the Mt. Vernon highway.

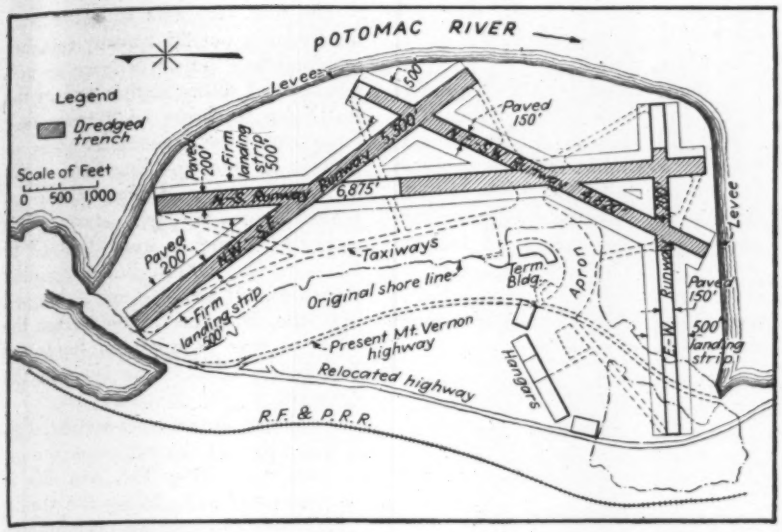


Fig. 2. Over four miles of runways and high visibility will make the new airport one of the country's finest. Trenches from which soft material has been dredged are backfilled with gravel for runway fills.

All hydraulic fill work was assigned to the Washington District office of the U. S. Engineers. The first job was to take 892 borings to determine geological conditions at the site and availability of suitable materials in the river. Soil samples from the borings were analyzed at the Ithaca laboratory of the Binghamton, N. Y., district. The basic drilling program called for exploratory holes on 500-ft. centers, supplemented by probing and jetting on 250-ft. centers. Investigations were made with three types of tests: type 3, drilled in 4-in. casing, 3-in. samples taken every 5 ft. with Moran & Proctor and split-spoon samplers; type 4 holes were driven with a 4-in. pipe to trap all materials, and the driving resistance was recorded; type 5 holes were driven by a well drill in 6-in. casing, 5-in. samples being taken with an M.I.T. spoon. Some of the last type holes were carried down 100 ft. so no undisclosed trouble might develop.

Surveys and explorations revealed that the average depth of water over the submerged area was 3.3 ft., and the average elevation of land was 5.8 ft. above mean low water. The geological formation consists of three materials. On top is a river silt from 5 to 20 ft. thick, except at the south part of the east boundaries, where it lies up to 45 ft. thick. The sand content of the silt is high enough to warrant its use as intermediate fill.

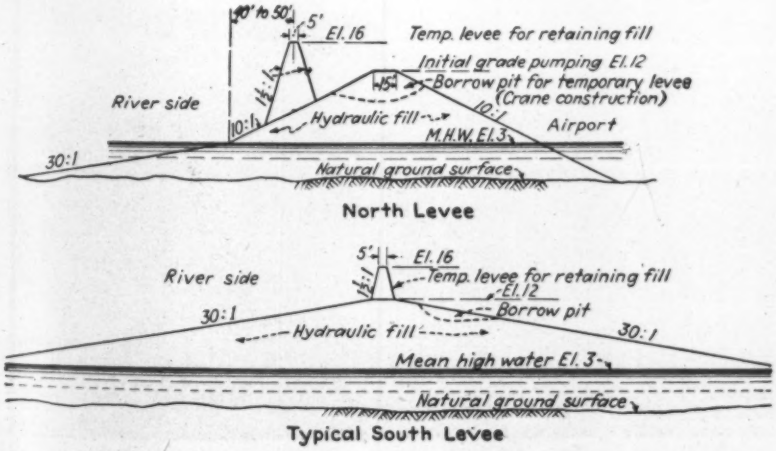


Fig. 3. Levees around the entire waterfront retain the hydraulic fill in the landing field. North and south levees are hydraulic fill; the east levee is partly a dragline fill on channel-dredging spoil banks.

Underlying the silt was found a stratified sand deposit about 50 ft. thick (except where the silt was deepest) containing lenses of gravel, cobbles and intermixed silt. Below this is interbedded stiff clay.

The primary requirement was to provide runways of uniform firmness to eliminate uneven settlement. Soil analyses showed that this requirement could be met by removing most of the compressible silt in the runway locations and backfilling with selected material available in the river bed. Desirable material for firm fills was determined to be that having a grain size above 0.06 mm.

The economical depth for trenching the runway areas was determined as El.—12 with a bottom width of 200 ft. regardless of width of runway. Dredging to this depth removed most of the soft muck under 17,000 ft. of the total of 21,257 ft. of main runways, though occasional muck pockets went deeper than 12 ft. On the remaining length of runway, principally on the east-west runway at the south end of the field, the muck was so deep that removing the top 12 ft. would contribute little to the stability of that runway. Consequently, in this deep muck area the silt is being removed or consolidated by controlled filling. The map Fig. 2 shows the runway locations and extent of trenching.

As an economical balance between cost of filling and desired flood protection, the average ultimate runway level, after settlement, was set at El. 13.7. This is well above the record Potomac River flood of 11.3 ft. in March, 1936, considered as a 70-year flood. A superflood of 15-ft. stage is considered possible every 235 years; all buildings and the loading apron are above this level. In considering flood possibilities, attention was given to the narrowing of the river from its former width of 6,000 ft. to 3,000 ft., but the dredging for fill material provides almost exactly the same cross section of flowageway.

Drainage of the field will be through catchbasins on a line 10 ft. out from edge of paving, connected to a sewer system. The drainage was designed for a rainfall of 3 in. per hour by the rational method formula: $Q = ACI$, in which C, the runoff coefficient, was estimated at 0.50 to 0.80.

To retain the fill and also for flood protection, 12,500 ft. of levee is required around the waterfront boun-

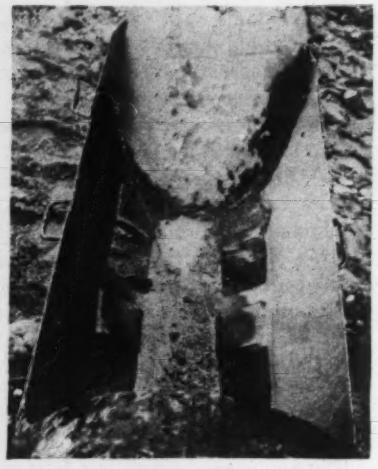


Fig. 4. Scour at end of dredge discharge lines is prevented by this special end section. Bottom pockets discharge heavy material; fines and water are spread over wide area by sloping end baffle.

dary of the field. This is all hydraulic fill pumped to El. 12, with a narrow top built up to El. 16 by dragline construction as a temporary fill retainer. On part of the east boundary only the dragline levee is necessary, as material deposited inside the levee lines from former channel dredging and local gravel operations rises well above water level.

For the north levee, where the silt is shallow, the embankment is built on 30:1 slopes below water level and 10:1 above, but along the deep muck south boundary the entire levee fill is built to 30:1 slope (Fig. 3). The stability of the levees was analyzed by the circular sliding theory; and the fills were figured to have a factor of safety of 1.5. It is considered safe to dredge the river channel as close as 200 ft. from toe of levee fill slope. As a protection against wave wash, the outer slopes of the 10,350 ft. of the levees will be faced with riprap.

Hydraulic fill operations

Because of the necessity of carefully selecting the dredged material, requiring frequent moving of the dredges, the army engineers decided to do the hydraulic fill work on a hired-plant basis rather than by contract. Four dredges are now at work: the army-owned 18-in. *Talcott*, the 27-in. *Pennsylvania* (American Dredging Co.), the 28-in. *Gulfstream* (McWilliams Dredging Co.), and the 27-in. *Lake Ellendale* (Standard Dredging Co.). Working 24 hr. per day, six days per week, they are pumping an average of 485,000 cu.yd. a week into the fill.

In the riverbed, within economical pumping distance of the landing field, 19,673,000 cu. yd. of suitable material is available. The net volume of required hydraulic fill is 11,370,000 cu. yd., which will necessitate pumping a gross volume of 14,500,000 cu. yd. The average length of pipe line required to transport this material is 4,800 ft.; the maximum length will be 6,000 ft.

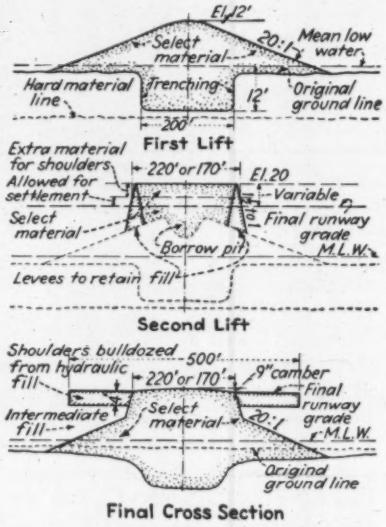


Fig. 5. Hydraulic fill for the runways is placed in two main lifts in the dredged trenches. Extra material placed on top accelerates settlement and compaction, also provides gravel for spreading over 500-ft. width for firm landing surface.

The first step was to get a start on dredging out the runway trenches and building the north levee to permit start of filling at that end of the field, also to throw up a temporary levee along the present highway to prevent its flooding. The *Talcott* and a smaller army dredge, since removed from the job, started this work. All trenches were dredged to El. —12 for 200-ft. bottom width; the sides, all under water, slumped but little. Material dredged from the trenches was pumped on land and into intermediate areas between the runways.

As shown in the cross-section, Fig. 5, the filling of the runways is done in two main lifts. The first lift is carried to El. 12, filling the trench completely and spilling over on side slopes of 20:1. Then retaining levees from 170 to 220 ft. apart, depending upon width of runway desired, are thrown up on both sides by dragline, using material bulldozed and scooped from the center of fill, to El. 20. The second lift of the hydraulic material fills the space between these levees to El. 20. The reason for the extra height of fill is three-fold: it provides for settlement to ultimate grade, it adds a surcharge to accelerate the settlement and consolidation of underlying material, and it allows sufficient extra material for spreading beyond the central fill to form shoulders that give an ultimate runway width of 500 ft.

Placing of the first lift in the trenches is done by end filling with

Fig. 6. Discharge from one of the four dredges. Note how material under pipeline is built up from discharge through bottom pockets in last three pipe sections. This view gives an idea of the character of material going into the runway fills.

two pipelines working toward each other. The lift is pumped to El. 12, a minimum height of 24 ft. above bottom of trench. Pipelines are carried on the new fill, extended a length at a time as filling progresses. The 24-ft. head of the heavier sand and gravel forces most of the silt remaining in the bottom of the trench ahead of the fill, though some of it is squeezed into the soft sides of the trench. Likewise, the lighter fines of the dredged material flow ahead into the unfilled trench section and are pushed along by the fill, though of course some of this finer material flows off to the side with the dredge effluent. Where the silt lies deep below bottom of dredged trench, it is well consolidated to firm foundation by the 24-ft. loading of heavy material. Behavior of the fill is constantly checked by borings. An attempt was made to reduce the height of the first lift, but investigation showed too much unconsolidated soft material was being trapped under the fill.

As the two pipelines approach each other, the trench becomes filled with silt and dredged fines. End filling is stopped when the approaching fills are about 200 ft. apart. A trapline (pipeline fitted with bottom discharge pockets) is carried across the gap on a trestle. Sand and gravel pumped through this line starts a longitudinal wedge in the soft material. As the wedge builds up it is widened until ultimately the entire gap has been filled with solid material and all silt is forced out through the sides of the trench. Borings show that this procedure makes a perfect closure. As a precaution, however, closure sections are planned away from intersection areas of the main runways.

In preparation for the second dredge lift draglines scoop out the center of the first lift to build levees on either side to El. 20. The trench between levees is then pumped full to El. 20 by end filling, the pipelines being carried on the ground. Side gaps are cut through the levees for escape of the dredge effluent.

To prevent scouring of the fill, the pipelines discharge through a special end section consisting of the lower half of a piece of pipe, containing several bottom pockets, and having a sloped baffle at the outer end. (Fig. 4). This arrangement drops the heavy, coarser material directly under the pipeline and distributes most of the water, carrying the finer particles in a wide spray. The two or three pipe sections next to the discharge are also equipped with bottom pockets for further deposition of coarser material in the center of the fill (Fig. 6).

The final step in building the runway fills is to bulldoze the surplus top material into shoulders to provide a firm landing strip 500 ft. wide. No work on this third stage has yet been done, nor have any of the taxiways been built. These will consist of select dredge material placed over the original ground. Excess select material is being stored at various points along the runways for later use as aggregate in portland cement and bituminous concrete paving.

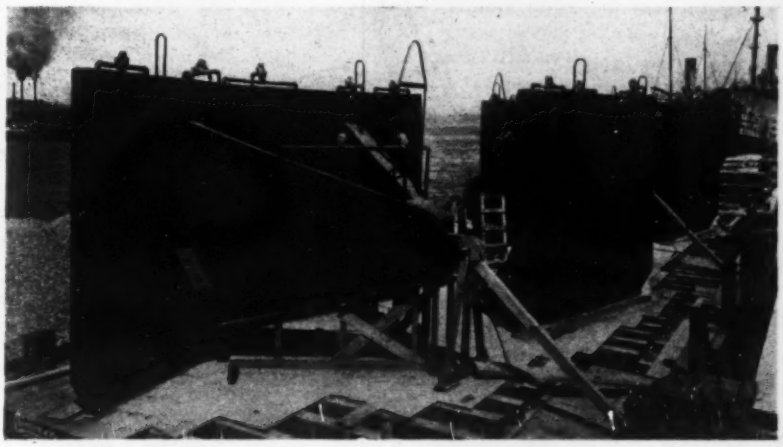
In grading the land section, about 750,000 cu. yd. of dry material will be available for spreading over the intermediate fill areas.

The project was authorized Sept. 1, 1938, and will be partly ready for service July 1, 1940. Several agencies of the federal government are cooperating in building the airport. The Civil Aeronautics Authority is responsible for general plans and development. PWA furnished the major share of funds as a grant of $6,300,000. WPA appropriated $3,586,561 and furnishes all common labor and minor materials. The Public Buildings Administration is designing the hangars and other buildings and will be responsible for their construction, not yet started. Relocation of the Mt. Vernon Highway is under the direction of the Public Roads Administration. An engineering commission of representatives of the various agencies coordinated the activities.

All hydraulic fill work is under the direction of the Washington District, U. S. Engineer Department. Col. R. S. Thomas, district engineer. On the work described here, Capt. J. B. Newman and E. J. Merrick are in charge.

Anchors for Pontoon Bridge Across Lake Washington

STEEL CABLES to hold barges of the Lake Washington pontoon bridge in place are to be attached to anchors on the lake bottom. For soft bottom a reinforced concrete anchor has been designed that can be jetted into the mud, thus getting it well bedded before tension is put in the cable. These soft-bottom anchors have chisel-edge bases and were cast with jet pipes embedded in the concrete so that water under pressure, admitted at seven points of entry, produces jets along the bottom edges and thus facilitates embedment. The anchors are lifted by the U-shaped rods.



Lake Washington pontoon bridge anchors ready to be transported to the point where it is to be sunk. The U-shaped rods are used for a 3-point crane pickup.

Plans For Flood Emergencies

ROBERT C. DARRAH
City Director, Real Property Inventory, Wheeling, W. Va.

Contents in Brief—A "disaster map" has been prepared for Wheeling, W. Va., which is designed to facilitate emergency efforts during periods of flood. The manner in which the map was made and the information it provides are described in this article.

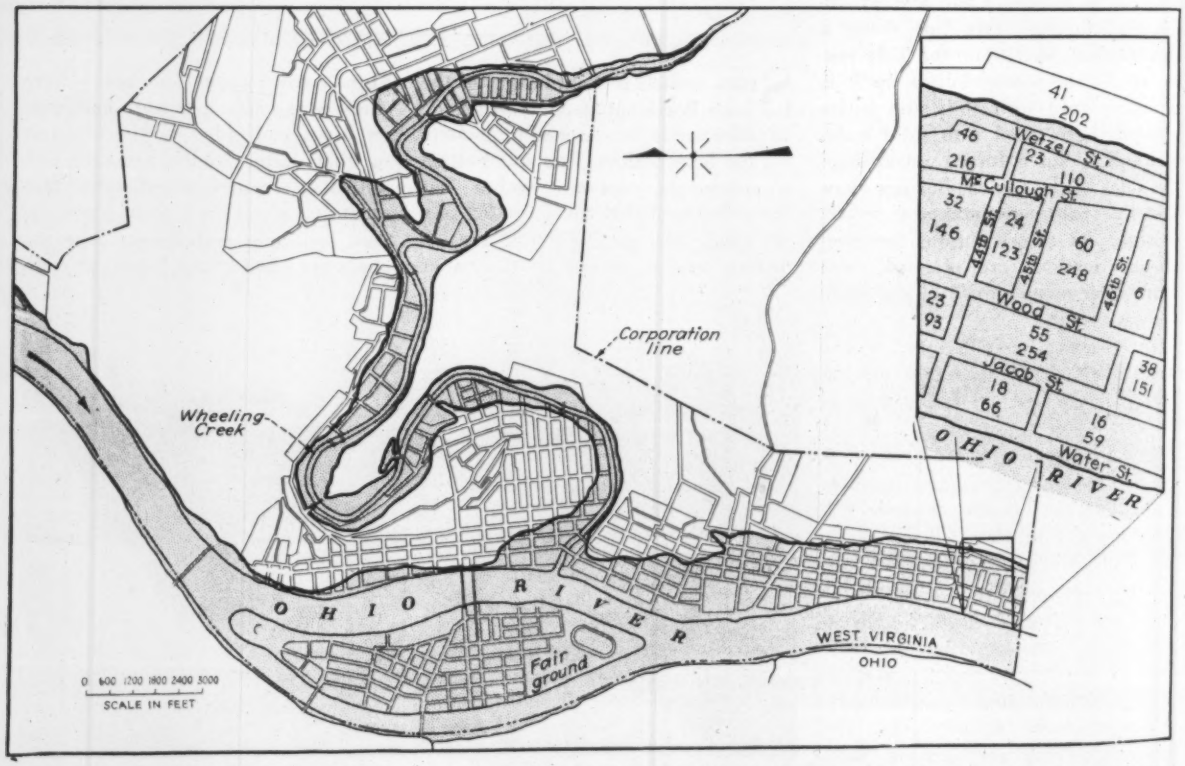
EVERY TOWN AND CITY along the banks of a river that occasionally goes on a rampage has a vital concern in planning for the inevitable "next flood." Bitter experience in Wheeling, W. Va., inspired the preparation of a disaster map on which has been recorded data pertaining to the number of homes, population, street elevations and other essential information in those blocks which might be subject to inundation during flood stages of the Ohio River.

A planned procedure reduces to a minimum the confusion of relief work, wasted effort and dangerous rescuing of stranded families. A properly documented map of the areas involved in the flood zone is a necessary requisite. With such a map, and with river stage forecasts several hours ahead, a disaster committee can intelligently plan: (1) in which city blocks to concentrate warnings; (2) an estimate of the number of families who will require help in moving household effects; (3) an estimate of the probable refugee load to be housed and fed, and where to do this; (4) where to direct refugees and emergency traffic; (5) prompt delivery of supplies to refugee centers apt to be isolated by flooded streets from main part of town; (6) rerouting of trucks and cars bringing supplies into city to avoid flooded highways.

With information compiled in a real property inventory, data were obtained on the number of dwelling units, and their population which could be recorded by city blocks on a map of Wheeling. From the city sewer maps it was possible to obtain the elevation of all principal street intersections, and these were readily converted from sea level to equivalent feet on the local river gage.

On the map the area that would be inundated by any given flood stage of the river is tinted. Additional area covered by increases in high water is tinted with other colors, thus picturing the area that would be flooded at any one time of several high-water stages. Automobile highways passing through the city are lined in red. At low points in the city where high water would flood roadways, the required river gage is marked.

Red-topped pins are used to indicate locations of churches, clubs, or large homes, whose kitchen equipment could be used during an emergency for refugee feeding centers. Green markers indicate the location of auditoriums, schools and churches where refugee shelters can be established. Location of temporary storage places near the feeding centers are



Outline of a flooded area in Wheeling, W. Va., at one stage of the Ohio River. The enlarged section of several city blocks (at the right) shows the number of dwellings and population in each block

noted by red and white markers. Green and white pins show the location of stocks of cots and bedding.

The disaster map was produced by the combined efforts of Walter C. Smith, city manager, Jay E. Henry, acting city engineer, Ellen Rochford, secretary of the Wheeling chapter of the American Red Cross, and the author. WPA funds were used.

Lean and Wet Slag Mix Makes Good Concrete

JOHN K. HARRIS
Superintendent of Construction, Republic Steel Corp., Cleveland, Ohio

Contents in Brief *— Slag concrete in the foundations of the Republic Steel Corp. mill at Cleveland, placed two years ago, gives every indication of being of high quality. The mixture used was characterized by a low cement content, contributing to economy, and a wet consistency, aiding placement. Feature of mix was substitution of fine graded slag for 20 per cent of coarse slag which improved workability and gave maximum density.*

CONCRETE placed in the foundations, floors, tunnels and walls of the 98-in. continuous strip mill of the Republic Steel Corp. at Cleveland, Ohio, is two years old and of such high quality as to give its designers special satisfaction with the mix used and the construction practices followed. Blast-furnace, air-cooled slag was used as coarse aggregate in all of the 125,000 cu.yd. of concrete required, and mixes were relatively low in cement volume and high in water content. Cracks are virtually non-existent, and the foundations have maintained the mill housings in perfect alignment. The slag concrete as designed is serving its purpose very satisfactorily, and was the means of effecting substantial savings in cost on account of the low cement factor.

An article in *Engineering News-Record*, June 10, 1937, p. 880, described the foundation work on this steel plant in some detail, and attention here is confined entirely to mix design, proportioning, mixing and placing.

Choice of slag for coarse aggregate rested on our belief that it was superior to other aggregates indigenous to the locality. In designing the mix we departed somewhat from standard practice, experience showing this to be necessary if best results are to be obtained in the use of slag. The fact that angular-shaped slag, with its decided cellular structure, contains a higher percentage of voids than rounded aggregates means that it requires a higher percentage of fine aggregate than gravel or limestone to achieve a workable mix. The usual practice is to add more natural sand, but for this concrete a slag sand was utilized.

For most of the concrete the aggregates were mixed in the proportion of one part cement, three parts natural sand and five parts slag by volume. The slag was well graded, having a maximum size of 1½ in. for some portions of the work and 1 in. for small wall and beam sections. A mix designed in these proportions, with the slag gradation in line with standard specifications, is obviously under-sanded. In order to correct this condition we departed from standard specification for slag gradation by reducing the volume of coarse slag 20 per cent and substituting a slag sand graded from ¾ in. down to dust. The modulus of fineness of this fine slag, commercially known as No. 7 grade, is about 3.30. This substitution of fine material produced a workable concrete of high quality. We found that the best results were obtained by maintaining the gradation of natural sand within certain limits, that is, modulus of fineness 2.70 to 2.86, with not less than 12 per cent nor more than 20 per cent passing a 50-mesh sieve.

A large part of the concrete was placed during the summer months and, except for floor slabs, no curing was done. In spite of this very little hair checking or temperature cracking has occurred. Included in the project were several walls and tunnels up to 700 ft. in length without construction or expansion joints of any kind. This work is almost entirely free from cracks, a condition probably due to the natural curing properties of the slag, especially the No. 7 grade.

Foundation and trench under table rolls of hot mill, typical of slag concrete used.

The quantities of materials used for 1 cu. yd. of concrete were: coarse slag, 20 cu. ft., weighing about 72 lb. per cu. ft.; fine slag, 4 cu. ft., weighing about 88 lb. per cu. ft.; natural sand, 14 cu. ft., weighing about 100 lb. per cu. ft.; and cement, 4.6 sacks.

Owing to the speed with which the work had to be carried on (2,500 cu. yd. per day at the peak of operations), it was impossible to maintain a low water-cement ratio, slump for most of the concrete placed being from 3 to 5 in., with corresponding compressive strengths of from 2,500 to 3,500 lb. per sq. in. in 28 days.

Concrete mixing plant

A central dry batching plant of four storage compartments—two for slag, one for sand and one for bulk cement—of sufficient capacity was constructed in close proximity to the site. The plant was equipped

with scales for weighing the aggregate for the batches. The cement was also weighed and automatically emptied into trucks, which hauled the batches to the mixers, which were placed close to the point of pouring. Each truck was equipped with three compartments, each compartment holding sufficient material to charge the 1-cu. yd. paving mixers used. Various methods of distributing concrete from the mixers to the forms were used, among them tower elevators and chutes attached to the mixer and portable belt conveyors.

The method of stocking the batching plant, while not original on this job, was quite novel. The coarse and fine aggregates were unloaded from drop bottom hopper cars into track hoppers and conveyed to stockpiles by means of belt conveyors located at right angles to the track. The piles of aggregate were in the shape of a frustum of a cone with a crater in the center, which served as a bin. The sidewalls of the craters, by obstructing the flow, prevented the material from segregating as it dropped into a tunnel which housed a belt conveyor leading to the batching hopper. Excellent gradation was maintained throughout the work in both the slag and the sand.

An important part of the job was the installation of 6,000 poured-in-place concrete friction piles of the tapered type averaging about 40 ft. in length, and of 12,000 of the stepped type of pile. In order to keep up with schedules it was necessary to place concrete in the shells immediately after the withdrawal of the driving mandrel. This necessitated concurrent operations with driving shells and placing concrete in the immediate area. Because of the continuous vibration and ground quaking occurring during the initial and final setting period, it was thought that the concrete might not attain a proper set. However, a thorough investigation of the results obtained has shown that the concrete will set properly under these conditions.

A construction expedient of interest was the placing of a submat 4 in. thick and unreinforced just below the top of the piles to support them laterally and to provide a working surface upon which the reinforcing steel for the remaining 20-in. thickness of the mat could be placed. The amount of cement in the sub-mat concrete was reduced 25 per cent below that used in the upper portion, thereby affecting a considerable saving. This mat has proved satisfactory in every way.

Truck Train Live Loading

WILLIAM E. WILBUR

Harrington & Cortelyou, Consulting Engineers
Kansas City, Mo.

THE CURRENT BRIDGE DESIGN specifications of the American Association of State Highway Officials give, as live loadings for long spans, the alternatives of a truck train or a uniform load plus a single concentration. The latter is subject to some uncertainty, since two concentrated loads are given, one for "moments" and one for "shears", with the division not clearly defined. To avoid this ambiguity, the accompanying chart (Fig. 2) was constructed. This chart gives, for any stress which has a triangular influence line, as in Fig. 1, a single equivalent concentrated load, which, applied at the apex of the influence line, gives the correct stress or moment for one lane of H-20 truck train loading. Its utility will be evident from the example given, and it is used by merely placing a straightedge on the chart, between the given values of long segment L, and short segment S and reading the equivalent load R.

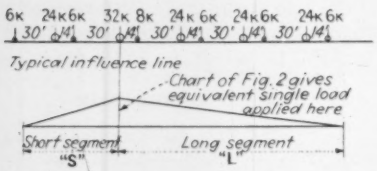

6K 24K 6K 32K 8K 24K 6K 24K 6K 24K 6K
30' 14' 30' 14' 30' 14' 30' 14' 30' 14'
Typical influence line
Chart of Fig. 2 gives equivalent single load applied here
Short segment "S"
Long segment "L"

Fig. 1. Diagram of and influence lines for H-20 truck train loading, an unlimited number of 15 ton trucks preceding and following a single 20-ton truck.

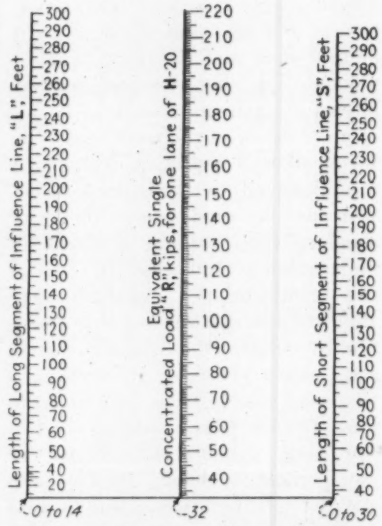

Length of Long Segment of Influence Line, "L" Feet
Equivalent Single Concentrated Load "R", Kips, for one lane of H-20
Length of Short Segment of Influence Line, "S" Feet
0 to 14
32
0 to 30

Fig. 2. Chart for determining an equivalent load for an H-20 truck train.

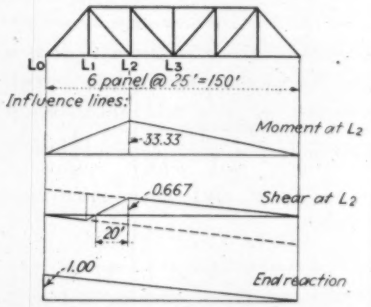


Fig. 3. Typical truss and influence lines for truck train loading.

As an example take the truss of Fig. 3, with influence lines as shown.

For moment at L_2:

$L = 100 \quad S = 50$

From chart $R = 63$k

Moment $= 63 \times 33.33 = 2100$ ft.k

For shear at L_2:

$L = 100 \quad S = 20$

From chart $R = 58$k

Shear $= 58 \times 0.667 = 38.7$k

For end reaction:

$L = 150 \quad S = 0$

From Chart $R = 75$k

Reaction $= 75 \times 1.00 = 75$k

When the length of segments exceeds 50 ft, the value of R may be obtained closely from the following formulas:

Two segments:

$$R = 1/3\ (L + S) + 14$$

Long segment only ($S = O$), for end shears and reactions:

$$R = 1/3\ L + 25$$

FIG. 1. SPOTTY LIGHTING IS CHARACTERISTIC OF TUNNEL ILLUMINATION OF A FORMER DATE.

Lighting the Modern Road Tunnel

R. W. SWETLAND

Illuminating Engineering Laboratory
General Electric Co., Schenectady, N. Y.

Contents in Brief—Adequate illumination calls for 2½ to 4 foot-candle average or more. Luminaires illustrated and light sources described for recent tunnel-lighting installations. Light location plan and luminaire design given for supplementary entrance lighting. Sodium illumination held to offer longer lamp life with smaller upkeep cost.

ALTHOUGH LIGHTING performs the same general function in tunnels as it does on streets and highways, the inherent hazards of tunnel traffic call for more perfect illumination. A blanket answer to the question, how much illumination, is extremely difficult because of such major influencing factors as: (1) length of tube and width of pavement; (2) one-way or two-way traffic flow; (3) average rate of speed of entering traffic; (4) average traffic density and load conditions; and (5) reflecting properties of tunnel lining and pavement.

Relatively low illumination levels, of from 0.5 to 1 foot-candle average over the pavement, are still found in vehicular tunnels which carry a heavy volume of traffic. In addition, a spotty distribution of light often prevails. Fig. 1 illustrates this type of inadequate illumination. Fig. 2 is an illustration of adequate tunnel illumination for the recently relighted (also relined and repaved) southbound tube of the Liberty Tunnel in Pittsburgh, Pa. An average illumination of 2.5 foot-candles is obtained over the entire pavement width. An average illumination over the pavement of 2.5 to 4 foot-candles also prevails in the McCallie Ave. Tunnel, Chattanooga, Tenn.; the Stockton St. Tunnel, San Francisco; the Beaucatcher Tunnel, Asheville, N. C.; the Salt Creek Tunnel in Oregon (now being installed); and a higher level of from 5 to 7 foot-candles is being contemplated for a new traffic tunnel in Montreal.

Recent practice

Tunnel-lighting systems are being planned today, with incandescent light sources on 20 to 30-ft. linear centers and opposite, with a 14-ft. ceiling height prevailing. There are also plans for the larger sodium light sources spaced 30 to 40 ft. in the 14-ft. ceiling type of tunnel, and from 50 to 60 ft. in tunnels having a 20 to 22-ft. arched ceiling construction. A considerable saving in both the initial and operating expense of the lighting system is thus effected, with no appreciable sacrifice in safe and comfortable visibility. Obviously, correct luminaire design is an important factor in improved control and distribution of light—materially aiding in this wider linear spacing of equipment. The following specific installations are cited as examples of present traffic-tunnel lighting practice.

Fig. 2 (previously mentioned) represents the largest installation of 10,000-lumen sodium lamps (238 luminaires) in traffic tunnel application in this country. Fig. 3 illustrates the enclosed-type sodium luminaire used.

The recently relighted Stockton Street Tunnel in San Francisco uses enclosed-type luminaires with 16,000-lumen sodium lamps. Local conditions dictated the use of existing ceiling outlets, providing a relatively low

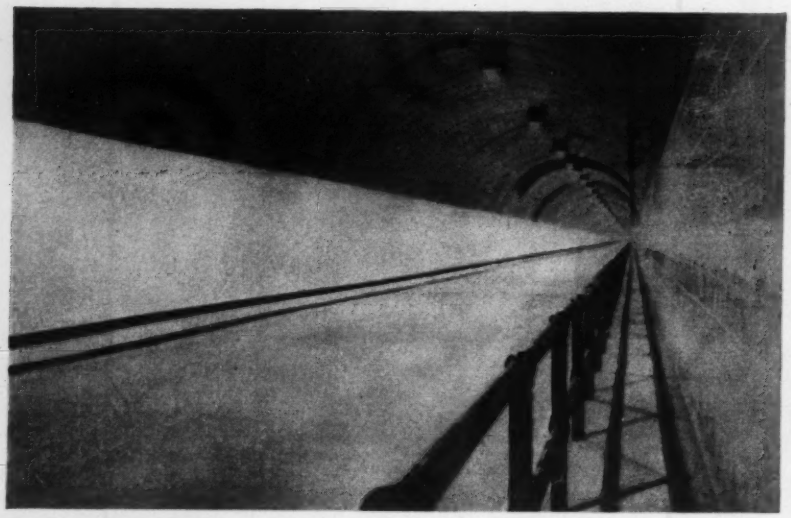


Fig. 2. Relighted and relined south tube of the Liberty Tunnel at Pittsburgh, Pa., represents modern illumination requirements.

mounting height of only 13 ft. above the pavement. Despite these limitations, excellent visibility and satisfactory light distribution are obtained. The relighted McCallie Tunnel at Chattanooga also has 10,000-lumen sodium lamps, suspended over the center of the pavement on 50-ft. spacings. More than 3 foot-candles of average illumination on the pavement (continuous operation) is the lighting level prevailing through this tunnel.

Fig. 4 shows the recently relighted Beaucatcher Tunnel in Asheville, N. C. Suspension-type incandescent luminaires (see Fig. 5) were used, equipped with 300-watt multiple-incandescent lamps, spaced 35 ft. apart over the center line of the roadway. A 21 to 22-ft. mounting height was maintained.

The Salt Creek Tunnel on the Willamette Highway in Oregon is lighted by sodium luminaires recessed in the ceiling, as shown by Fig. 6. Sixty-five luminaires, equipped with 10,000-lumen lamps, are involved in this installation. A 40-ft. linear spacing, with a 21-ft. mounting height, is maintained.

The most economical and advantageous method of energy distribution for tunnel illumination—whether by means of multiple or series circuits—is governed largely by the length of the tunnel under consideration and by such other factors as (a) desirable or permissible transformer locations, (b) available duct space, (c) desired method of control, and (d) possibility of reserve capacity on an existing adjacent lighting circuit. In general, series circuits or a high-voltage, constant-potential circuit perform to the best advantage in the longer tunnels, and in other instances where conduit space may be at a premium.

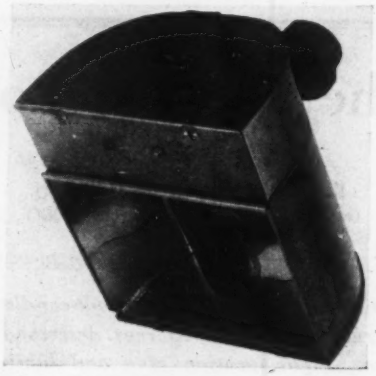


Fig. 3. One of the 240 enclosed-type sodium luminaires with 10,000-lumen lamps used in the Liberty Tunnel.

Supplementary entrance lighting

Any adequate consideration of the subject of tunnel illumination must necessarily include mention of the very real problem involved in minimizing or eliminating the momentary but hazardous loss of visibility as a motorist enters a straight tunnel section from bright sunlight conditions outside. Furthermore, at a speed of from 35 to 40 mph, some 200 ft. or more of a tunnel section is traversed before the average eye produces sufficient pupil expansion for safe vision.

Every modern tunnel-lighting system, therefore, should include some effective method of preserving adequate vision during this critical transition period. Outside the tunnel there may be several thousand foot-candles of sunlight; inside the portal, there may be only from 2 to 4 foot-candles of artificial illumination. Although further study will undoubtedly be given to this problem, there already exist, in actual application, two or three fairly effective solutions.

Method No. 1. An overhead louvered ceiling structure has been built for a distance of some 200 ft. out from each portal of the Broadway

Fig. 4. Incandescent 300-watt lamps spaced 35 ft. apart were used in relighting the Beaucatcher Tunnel at Asheville, N. C.

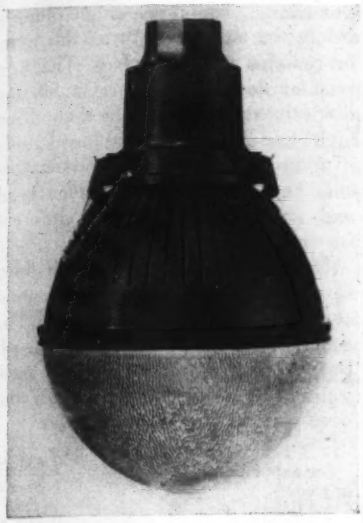


Fig. 5. Suspension-type incandescent luminaire used in the Beaucatcher Tunnel.

Tunnel in Oakland, Calif. (*ENR*, Feb. 17, 1938). These ceiling openings are so designed as to permit no direct sunlight to strike the pavement and to produce a diminishing level of daylight illumination as the motorist proceeds in toward the tunnel portal. Granted that such a device minimizes the loss of visibility during the transition period from daylight to tunnel illumination, yet local construction conditions might justifiably eliminate this procedure from many tunnel projects. Furthermore, in northern climates a hazardous condition of icy pavement beneath this structure would undoubtedly prevail many times during the winter.

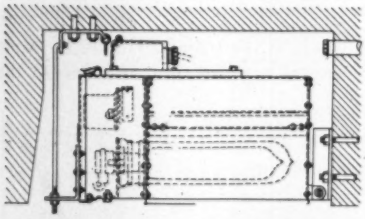


Fig. 6. Luminaires with 10,000-lumen sodium lamps are recessed in the ceiling of the Salt Creek Tunnel on the Willamette highway in Oregon.

Method No. 2. Tunnel entrance sections which are built on a pronounced curve in the roadway—with preferably an additional belling-up of the ceiling to permit greater daylight penetration—quite effectively silhouette entering vehicles against the background brightness of reflected light from this outer sidewall of the curve. Here, again, local conditions might well render such a method of tunnel construction impracticable.

Method No. 3. Several actual tunnel installations, plus laboratory experiments, indicate the effectiveness of an adequate level of graduated artificial illumination along a 200 to 300-ft. section of the tunnel entrance, in minimizing momentary loss of visibility. Straight incandescent, or a combination of mercury and incandescent illumination, seems most effective and economical for this purpose. Larger incandescent lamps, of 1,000 to 1,500 watts in size, can be used effectively in obtaining the relatively high level of illumination necessary to accomplishing this objective under severe conditions of daylight brightness outside the tunnel.

Fig. 7 illustrates one recommended arrangement of ceiling-recessed incandescent luminaires for this supplementary entrance lighting of a highway tunnel. A suggested design of flush-type ceiling luminaire, capable of accommodating several sizes of lamps, is shown by Fig. 8.

Comparison of illuminants

Several of the foregoing illustrations indicate that sodium illumination is already finding a place in vehicular tunnel lighting. This is a logical development, due to two outstanding advantages inherent in the sodium lamp. First, sodium lamps are more efficient than incandescent lamps suitable for tunnel application. The output is 55 lumens per watt initially for the sodium lamp, as compared to from 15 to 20 lumens per watt for the incandescent. The second advantage is the long burning life of the sodium lamp when operated continuously. Laboratory life tests have revealed more than 8,000 hr. continuous burning, and individual sodium lamps have reached 10,000 hr. in one actual tunnel installation. Two other tunnel projects show more than a 6,000-hr. average for the sodium lamps to date, with 70 per cent of the original lamps in one project still in service. Such actual experience and data indicate that a 4,000-hr. life may be taken as a conservative average for sodium lamps in continuous operation. That amounts to about two renewals annually per luminaire.

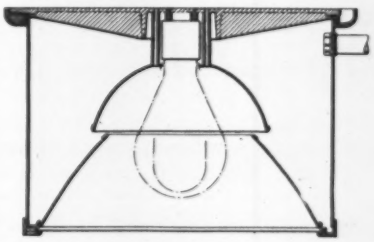


Fig. 8. Proposed flush-type ceiling luminaire for tunnel entrance lighting.

In view of these established facts, a given level of illumination in traffic tunnels usually can be provided by sodium lamps at a 30 to 70 per cent decrease in annual maintenance cost as compared to incandescent lighting. Obviously, such influencing factors as type of luminaire and circuit equipment, energy cost and the average level of illumination desired, introduce a variable economy. The recommended 10,000-lumen a.c. sodium lamp may be operated satisfactorily from either a 6.6-ampere constant-current series circuit, or from a multiple circuit.

While both mercury and fluorescent lamps have been investigated as possible illuminants for tunnel use, at present there is a lack of dependable data relative to the operation of these lamps on continuously burning circuits.

Indicative of the study now being given to the most effective methods of tunnel illumination, is the model tunnel section—built to a one-eighth full-size scale—in use at the Illuminating Engineering Laboratory of the General Electric Company at Schenectady. While further progress in tunnel lighting practice is to be expected, it is believed that the foregoing data merits thoughtful consideration by those who are concerned now with tunnel projects.

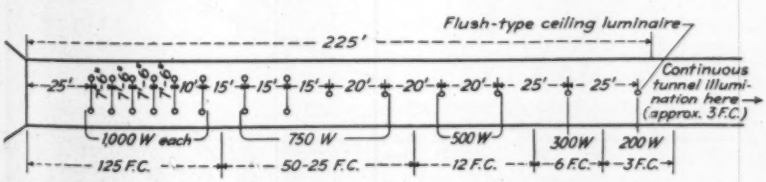


Fig. 7. Proposed plan for supplementary entrance lighting to accustom vision to change from outside sunlight; operated only in daytime.

Submerged Weir Formula Verified

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General formula developed in laboratory tests gives results in close agreement with observed values on a completed structure

OBSERVED hydraulic data presented in a recent article (*ENR*, Jan. 27, 1938, p. 137) describing the characteristics of a submerged weir-type dam built by the CCC show close agreement with computed values for head obtained by the use of a general formula developed experimentally. Although the reported observations were made on a weir whose crest was not identical in shape with the experimental weir, and although the heads observed were much greater, the numerical difference between values amounted to only 1.7 per cent.

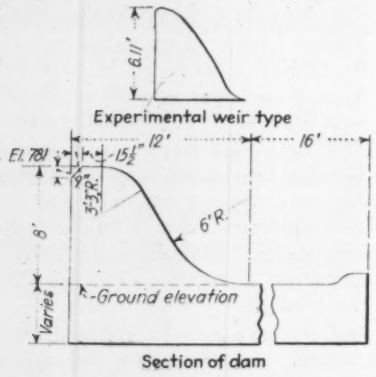

Fig. 1. Maximum section of the experimental weir compared with the section of the CCC dam.

The general formula was developed by the author at the University of Wisconsin, following the conclusion of some 2,700 tests on flow over submerged weirs of the sharp-crested and ogee type. The ogee types had both vertical backs and 2 to 1 upstream faces with heights of crest ranging from 1.14 to 6.11 ft.; the head during the tests varied from about 0.1 to 2.1 ft. Information contained in the article by C. H. Eiffert on the performance of a low concrete dam built in the Miami Conservancy District furnished an opportunity for testing this formula on a higher weir and with much greater heads than those used in the tests.

Development of formula

Water flowing over a submerged weir forms a trough downstream from the crest and this is followed by some rise in the water surface. It was found advantageous, therefore, to measure the downstream head in this trough. The nappe either plunges below the surface right at the weir, or remains on the surface. The first type of flow is the more stable for low submergences and the second for high; however, there is a considerable overlap in which either type may occur. The discharge for a given head and submergence is quite different for the two types of flow.

Due to the different types of flow, it was necessary to write two general equations for each type of weir. The general formula $Q = CLH^n$ was used. Both C and n varied for the ogee weirs. The derived equation for the ogee vertical back weir follows:

$$\text{For nappe under, } C = 3.895 - \frac{0.433\ S^3}{1.35 - S}$$

$$\text{and} \qquad n = 1.625 - \frac{0.140\ S^3}{3.0 - S}$$

$$\text{For nappe over, } C = 3.895 + 0.01064\ P - \frac{(1.52 - 0.1886\sqrt{P})\ S^3}{1.433 - 0.01353\ P - S}$$

$$\text{and} \qquad n = 1.625 + \frac{0.036}{\sqrt{P}} - \frac{\left(\frac{0.428}{P - 0.169} - 0.0129\right) S^3}{0.886 + \frac{1.31}{P} = S}$$

Where C = coefficient in $Q = CLH^n$
L = length of crest in ft.
H = observed upstream head plus $V^2/2g$
n = an exponent
P = height of weir crest in ft.
S = submergence expressed as a decimal

Mr. Eiffert courteously furnished large-scale rating curves and plans of the layout showing the type of crest and the position at which the heads were measured. The downstream head was observed very nearly at the trough. Due to the same general type section and due to the

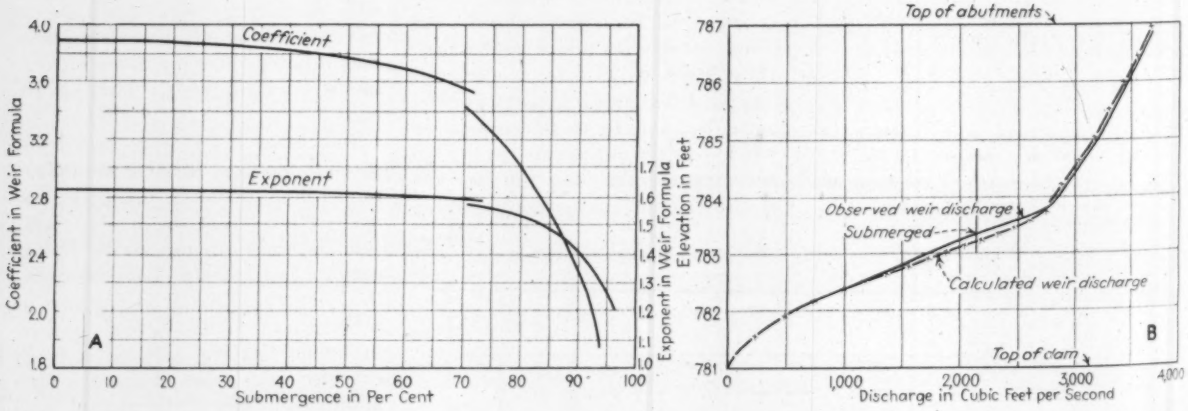

Fig. 2. Values of coefficients and exponents for an ogee vertical-back weir having an 8-ft. crest height are shown in (A) and the calculated and observed rating curves for the CCC dam are given in (B).

fact that readings of the downstream head were made in the trough, the above quoted formula was applied without change. Computed values of C and n appear in Fig. 2A. A comparison of the observed discharges with the calculated ones appears in Fig. 2B. The break in the calculated discharge at 2,700 cfs occurs at a submergence of about 70 per cent and the author has presumed that the nappe plunged over at this submergence. The values of the coefficient and exponent for zero submergence were used for the computation of the freefall discharge.

The maximum difference between the observed and calculated upstream heads is 0.16 ft. and occurs for an upstream head of 2.4 ft. This difference is less than 7 per cent. The numerical difference between the two heads decreased for further increase in head and amounted to 0.10 ft. with a head of 5.85 ft. This difference amounts to 1.7 per cent.

Electric Heat Speeds Curing Of Precast Concrete Joists

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Contents in Brief — Pouring I-shaped concrete joists side by side leaves an opening along the webs into which a coil of lead-sheathed electric cable was inserted to impart 40 watts of heat per foot. Efficiency increased, output doubled, cost small. The capital expenditure necessary was less than $75. This article is from a paper that won fourth prize in General Electric contest on applications of electric heating.

A LARGE INCREASE in efficiency in molding precast concrete joists has been achieved by Joseph Nagy of the Columbia Concrete Block & Supply Co., Toledo, Ohio, through the use of electric heat for curing. Previously, artificial heat for accelerated curing had been obtained from salamanders placed directly under the molds. This permitted removing joists from molds in 5 to 7 hr. as against 10 hr. when no external heat was used, but there were disadvantages: salamanders required that the room be entirely closed, and other work in it stopped; temperature control was uncertain; and there were labor charges for building and maintaining the fires. By experimenting with electric heat it was found that 800 watts would bring a 20-ft. joist to 160 deg. F. in 2 hr.

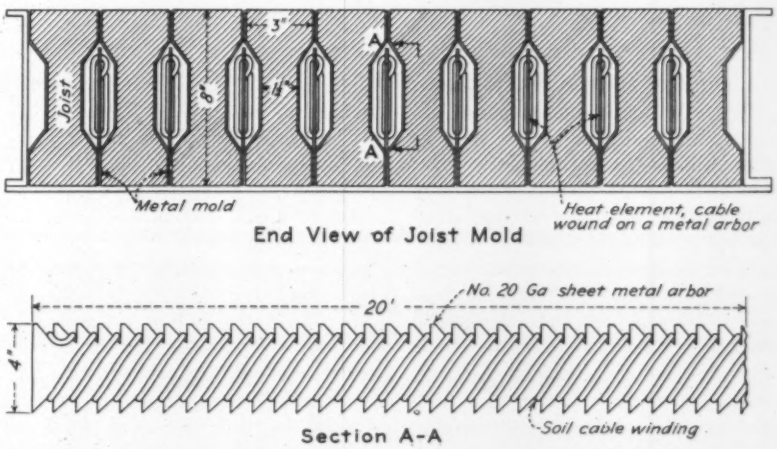
The heat was applied by utilizing the spaces in the hollow metal cores of the joist mold, as shown in the accompanying sketch. The heating element utilized was lead-sheathed soil cable which had the necessary properties: low density, flexibility, waterproofness, and the ability to support the required temperature range. In designing this heat element the principal problem was to arrange the cable to secure the proper watt density and to avoid contact with the metal molds; air being the medium of heat transfer, even distribution was assured.

The mold consists of a steel frame designed to take ten 8-in. joists of any length up to 20 ft. Individual joists are formed with the use of hollow fabricated metal cores, forming a space between adjacent concrete joists about 4¾ in. high and 3 in. wide. An arbor of 20-gage sheet metal, notched so as to space the cable evenly and permit 6 ft. of cable per ft. of arbor, was designed to be inserted in each of these hollow spaces. Thus, there are nine arbors in a mold for ten joists, each 20 ft. long and containing 120 ft. of soil cable on 230 volts. The connected load is 7.2 kw.

Precautions were taken in winding the arbor to see that the sharp corners of the sheet metal did not cut through the lead sheath of the cable. The wound arbor rests in the space between the molds in a vertical position. The top and bottom of the space being V-shaped, no support is needed to hold the arbor in place, and it may be removed readily in case of an emergency. Although no thermostat has been used, it would be advisable to install one to protect the cable from overheating.

Present production procedure is to pour the concrete in the mold, to apply heat for 2 hr., and strip the mold in 5 hr. For a cost of 1.6 kwh per 20-ft. joist, the output of the mold has been doubled and the working conditions improved immensely, while the space in which the molds are located is usable at all times. The capital expenditure was less than $75.

The method employed was to pour one mold in the morning, apply heat so that the forms could be stripped in the afternoon, and then pour a second set, letting it stand overnight without heat.



Detail of precast concrete joist molds wired for curing by electric heat. The wiring is carried on a special frame to avoid contact with the metal molds.

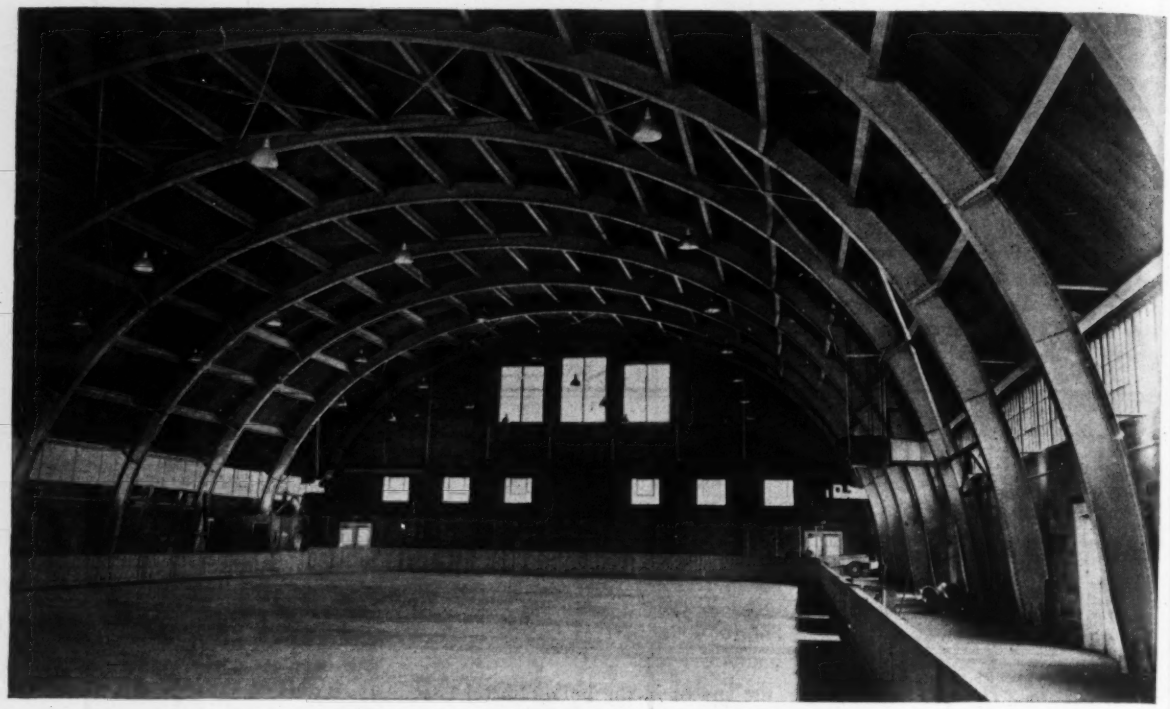


FIG 1. ARCH RIB ROOF SUPPORT FOR BOSTON SKATING CLUB RINK.

Simple Arch Roof for Boston Skating Rink

C. M. SPOFFORD

Fay, Spofford & Thorndike, Consulting Engineers, Boston, Mass.

Contents in Brief—Special requirements of the Skating Club of Boston led to the design of a rink using arch rib roof supports shaped to a three-centered curve. To minimize heat transmission the walls of the enclosure were made of hollow cinder blocks, the underside of the roof was covered with insulating board, and in the windows a heat-absorbing glass was specified.

ARCH RIB ROOF SUPPORTS shaped to a three-centered curve distinguish the design of the new ice rink built for the Skating Club of Boston. This shape provides minimum interference with the seating capacity along the sides of the ice surface and at the same time provides ample roof height for efficient lighting, heating and ventilation. Other interesting features of the construction include the use of hollowed cinder blocks for walls, and the installation of a wood plank roof faced with an insulating material on the underside.

The Skating Club of Boston, one of the earliest organizations of its kind in the United States, was restricted in its activities by the necessity of practicing in a public rink. Following a decision to build its own rink the club awarded a contract for construction in August, 1938, and on the following New Year's Eve the members occupied the rink for the first time.

As illustrated by Fig. 1, the roof is supported by two-hinged arch ribs which are of uniform depth. The horizontal thrusts of the arches are carried by the walls and roofs of the pipe galleries which surround the building. In order to avoid using a clumsy and expensive pin and shoe hinge, the simple hinge shown in Fig. 2 was developed by the engineers and the New England Structural Co., contractors for the steelwork.

The arch ribs are made up of 24 by $\frac{3}{8}$-in. curved plates with 6 by $3\frac{1}{2}$-in. flange angles with the 6-in. leg horizontal. These angles vary in thickness from $\frac{1}{2}$ to $\frac{11}{16}$ in., to correspond to the maximum stresses occurring in each of the three sections into which the rib is divided by the two field splices.

In order to erect the arch ribs without falsework the three sections of each rib were riveted together while lying on the ground, and the rib was then rotated and swung into position. Since a rib was very flexible at right angles to its axis, it was necessary to lift it by a 3-point suspension device provided with a strut in the plane of the rib between the two extreme points of suspension.

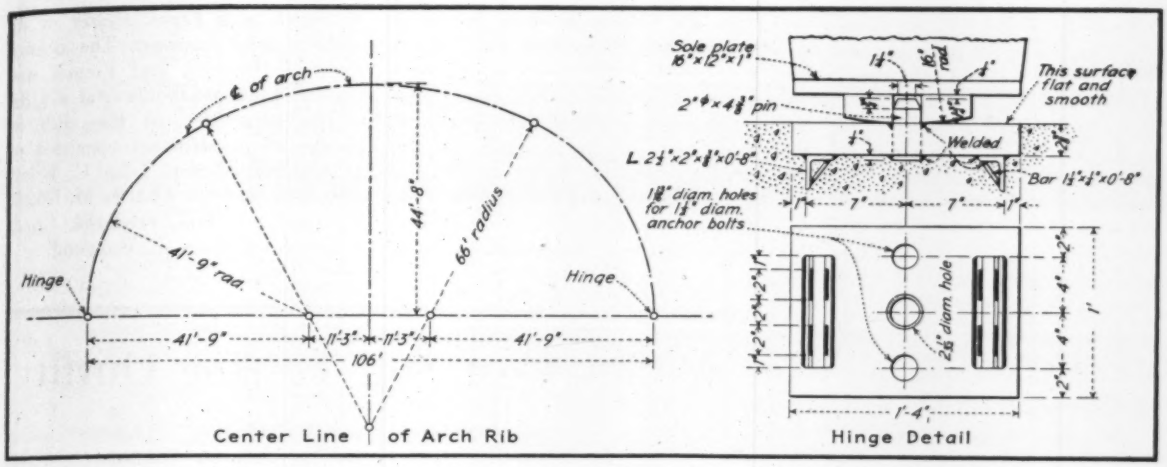


Fig. 2. Form of the three-centered curve to which the arch was shaped, and (right) details of the hinge connection.

The purlins are 12-in. 25-lb. wide flange beams, and are placed at varying angles with the arch ribs in order to develop their maximum strength.

The roof consists of 2-in. tongue and groove yellow pine planks made up into panels before erection, except for the overhanging portions at the eaves. On each panel a thermal insulating material about ¾ in. thick was nailed to the underside before the panel was put into place. The insulating material was coated with an asphaltic compound at the works and dusted with aluminum powder while still soft. The roof is covered with a rolled roofing substance which is fire-resisting, waterproof and of clover green shade, a color which combined favorably with the gray walls.

The walls are formed of 8-in. cinder blocks as shown in Fig. 3. These blocks are not solid, the weight per square foot of wall being about 35 lb. The side walls are 16 ft. in height. All exposed structural steel both inside and outside was painted with aluminum paint.

The building is divided longitudinally into ten bays giving a total length between centers of end trusses of 204 ft. Transverse bracing is used in each of the end bays and in the fifth bay from the north end. The lowest panels of bracing are of the portal type so that the bracing does not interfere with seating capacity or entrances.

The structure, exclusive of service and locker room, which are located at one side of the building, and of the clubhouse now under construction at one end, covers an area of 207 by 110 ft. The ice surface is 193 by 85 ft., thus providing a full-sized hockey rink.

A pipe, wire, and drainage gallery surrounds the building and is underneath the spectators' platform, which adjoins the ice surface. The inside walls of this gallery serve as retaining walls for the sand and gravel fill upon which the floor rests.

One of the "must" requirements of the design was that the ice surface should be absolutely level and remain so. The natural ground, which contained some peat, was therefore excavated below the peat surface and filled in layers with a sandy gravel material and 18 in. of cinders. Each layer was thoroughly rolled. The surface was then finally rolled with heavily loaded trucks to assure thorough compaction.

A 5-in. reinforced-concrete slab was laid directly on the fill. Upon this slab and properly supported thereon were placed a series of hairpin loops of 1¼-in. steel pipes for the circulation of the brine used for freezing. Each loop is supplied with shut-

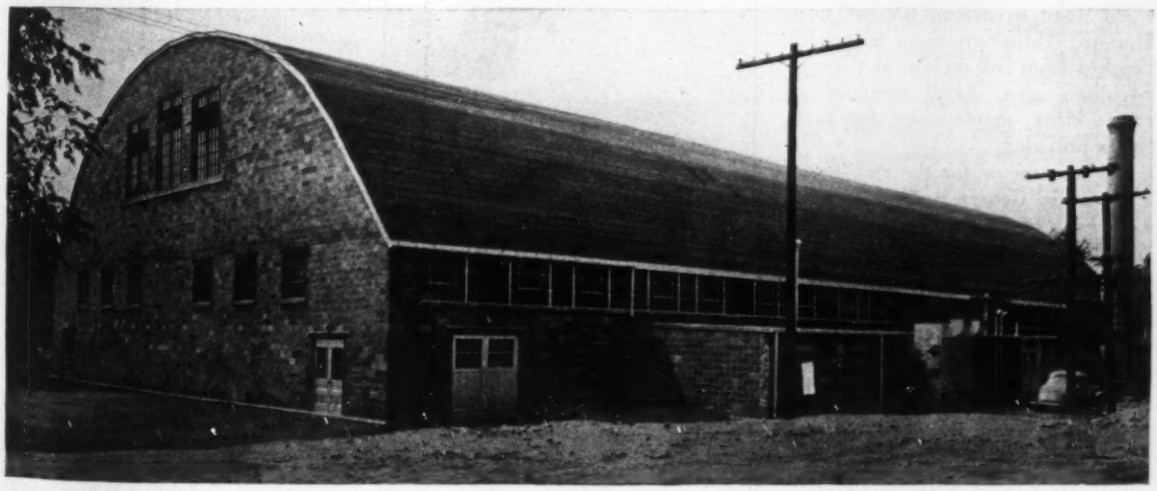


Fig. 3. Cinder block walls, an insulated roof and heat absorbing glass in the windows are features of the rink enclosure.

off valves which can be operated from the pipe gallery. A brine temperature of 18 deg. F. is ordinarily used. Concrete was placed around the piping to form a top floor slab.

As it is essential that the ice surface should not be exposed to direct sunlight, heat-absorbing glass was used in all windows except those on the north side. Artificial light for night skating is provided by thirty-six 1,000-watt overhead lamps. The rink is heated by six unit heaters which are so controlled as to maintain a temperature sufficient to keep the ice properly tempered for skating.

The rink is open to members in three sessions: morning, afternoon, and evening. After each session the ice surface is scraped, sprinkled with warm water, and refrozen. Occasionally the surface is planed by a steel planer dragged by a tractor in order that the ice may be kept at a reasonable thickness to reduce the expense of freezing. The freezing equipment now installed is designed to provide an ice surface over the entire rink area during the period from Oct. 1 to May 1, but is so designed that if a demand for summer skating occurs the addition of one more compressor units will make it possible to provide an ice surface over the entire area during the summer.

An attractive two-story clubhouse is now under construction at the north end. The upper story contains a lounge fitted with large observation windows on the side adjoining the rink to provide a gallery for spectators. To prevent damage from flying pucks the observation windows are made of a tempered plate glass.

The rink is located on Soldiers Field Road in Boston not far from Harvard University and is readily reached from any section of the metropolitan area. As it occupies an entire block, ample space for parking is provided.

The contractor for the rink building was the George B. H. Macomber Co., Inc., of Boston; and the contractor for the clubhouse is Charles S. Patten, of Melrose, Mass. The freezing equipment was furnished by the Frick Co. of Waynesboro, Pa. The New England Structural Steel Co. of Everett, Mass., fabricated the steel, which was erected under its supervision by Daniel Marr & Sons of South Boston; the curved web plates are Lukens Edge Eend plates made by the Lukens Co., of Coatesville, Pa. The angles were furnished by the Bethlehem Steel Co., which also punched the rivet holes in them prior to shipment. The rivet holes in the curved plates were drilled at Everett to match the holes in the flange angles.

Fay, Spofford & Thorndike, consulting engineers of Boston, prepared the design and supervised the construction, with Frank Holzer of its staff as field engineer. The Boston firm of Hutchins and French was consulted upon architectural details.

The committee of the club in charge of construction consisted of L. Gordon Glazier, John C. Kiley, James L. Madden, Charles M. Rotch, George E. B. Hill, Frederick Goodridge and Richard L. Hapgood.

A Low Cost Soil Testing Outfit

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Contents in Brief — Descriptions and working drawings of soil testing apparatus that can be made in any college or highway department shop at costs within the means of the most scanty of budgets.

THE INCREASING PRACTICE of using soil tests as a means of control for embankment construction, foundation design, road bases and other earthwork has set up the problem of providing laboratory apparatus that does not run into heavy expense. As an aid in solving this problem, drawings and descriptions are given here of soil test apparatus that meets most purposes and is simple to construct at moderate cost. The illustrations and descriptions apply specifically to apparatus installed at Columbia University, New York City, and designed for the common specimen-holding devices; simple modifications will fit the stands for other laboratory conditions.

The consolidation loading apparatus, Fig. 2A, is a simple counterbalanced beam system of the increment loading type using dead weights. The beam is cold-rolled steel with the knife edges exactly on line. Weights of lead are adjusted for loads of $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, 4, 8, and 16 tons per square foot. The loading frame is of angles bolted together. It is preferable to bolt the frame to a concrete pedestal, cast separate

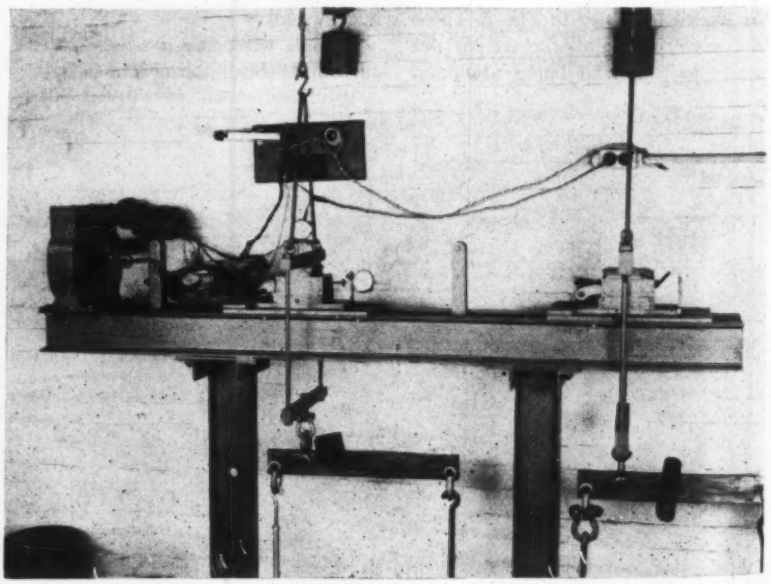


Fig. 1. Inexpensive stand for laboratory shear tests of soils using two test boxes.

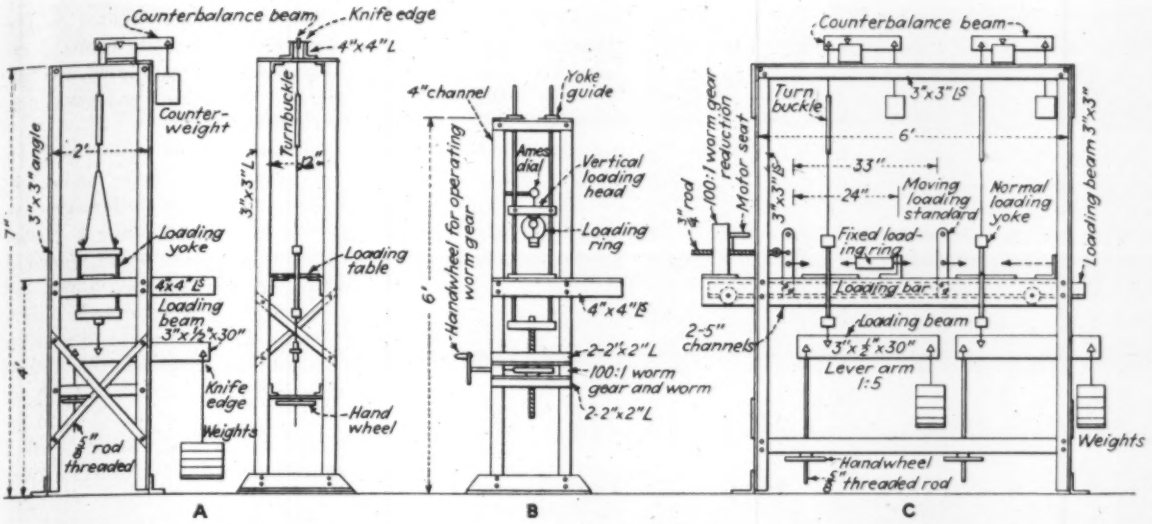


Fig. 2. General drawings of stands for soils tests: A, consolidation loading; B, unconfined compression; C, shear test.

from the floor to minimize vibrations. The elevation of the weighing beam is adjustable to accommodate any height of consolidation device; it is kept reasonably level during the test by a large hand wheel, running on ball bearings, at the fixed end of the beam.

Compression test stand

The unconfined compression test requires an apparatus of the vertical loading type, which permits load to be applied at a continuous and constant rate. The constant-strain type of loading apparatus is the simplest to set up. In the case illustrated in Fig. 2B a small tension testing machine was adapted for the test. Load is applied by a vertical loading head, running in guides and manually operated through a worm gear reduction, 8-in. worm, 100:1. The gear reduction is such that the speed of the loading head can be readily made to vary from 0.2 to 0.05 in. per minute. With a little practice and with observations of time against vertical dial movement the rate of loading can be kept quite constant.

The load is measured directly between the loading head and the specimen by a calibrated loading ring and a 1/10,000 Ames dial, which are attached directly to the loading head. The loading ring has a capacity of 600 lb., the value of one division on the dial is about 1.5 lb. The load is transmitted through the loading ring to the specimen by a small spherical block to give good end bearing contions.

The vertical compression of the specimen is measured by a 1/1,000 Ames dial attached to an adjustable arm and bearing directly on the loading head. For very stiff materials the vertical compression of the specimen is corrected for the compression of the loading ring by deducting the dial readings. For very weak materials a second loading ring of less capacity and greater sensitivity is used. The loading mechanism may be motor operated.

Shear test stand

In general, shear testing apparatus is more complicated and more expensive. The simple shear testing bench, illustrated in the photograph, Fig. 1, is made to accommodate two shear boxes, but can be constructed longer to accommodate any number of boxes, using the same shear loading unit for all. The normal load on the shear specimen is applied by a simple counterbalanced loading beam system and dead weights. For the set-up shown the bottom of the shear box is fixed and the upper half is sheared. The distance between the points of support of the loading beam and the counterbalance beam is made as large as possible so that a very slight and in this case a negligible force is required to deflect the beam system up to the limit of the horizontal shear deformation required by ordinary materials. The load on the loading beam holds the yoke vertical. The elevation of the loading beam is adjustable vertically to accommodate any height of shear box, using a hand-wheel at a fixed end of the beam support. A simple shear testing apparatus can be built up as illustrated in Fig. 2C, in which the upper frame of the shear box is now fixed and attached to a fixed loading ring, and the lower frame is attached to the moving loading bar.

The horizontal shearing load is applied through a 100:1 worm gear (8 in.) reduction by a heavy-duty 1/20-hp motor (AC or DC), having a 34:1 worm speed reduction, the shaft speed being 340 rpm at full motor speed of 10,000 rpm. The motor is a four-wire lead reversible type. The rate of horizontal loading can be adjusted by a rheostat to vary from 0.2 to 0.05 in. per minute and kept constant by a slight adjustment of the rheostat as load is applied. The shearing apparatus operates as a constant-strain type. The shearing load is transmitted through a long horizontal loading bar, which consists of a T-beam running on wheels equipped with ball bearings on the inner lower flanges of the I-beams or channels. A vertical standard is attached to the loading bar for each shear box.

COST OF SOIL TEST APPARATUS AS DESCRIBED

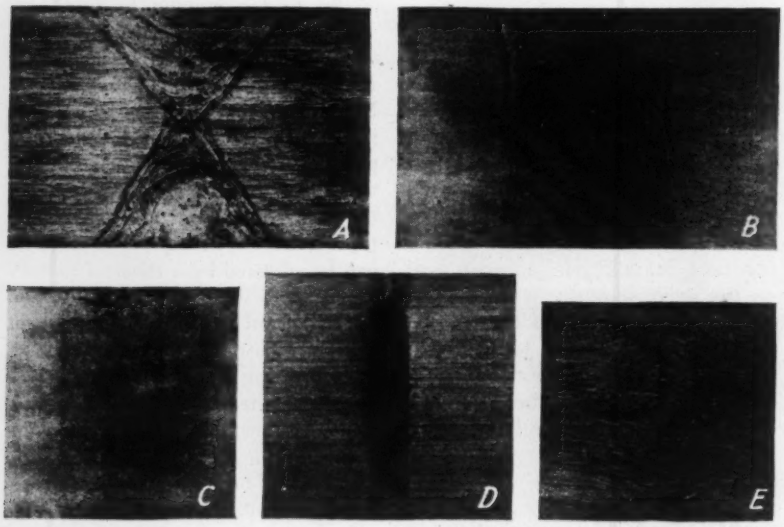
Apparatus	Structural steel at 6c. lb.	Counter-balanced beam assembly	Bearings, worm gears miscellaneous	Motor, motor assembly, etc.	Machinist labor, hrs.
Consolidation	$17	$9	$2	..	40
Unconfined compression	$11	..	$11.50	..	30
Shear	$27	$18	$10	$40	100
Loading ring assembly with Ames dial					$40

The horizontal shearing load is measured by a calibrated loading ring and a 1/10,000 Ames dial attached to a bracket. The loading ring is equipped with a special hook for applying load to the upper frames of the shear box. The position of the loading ring and the hook is adjusted to give a horizontal pull. The loading ring is calibrated by dead weight in tension and has a capacity of 600 lb. (An outer race of a 6-in. ball bearing makes an excellent loading ring). It can be readily shifted to either of the two standards, so that either of the shear tests can be made independently of the other. Thus while one sample is being preconsolidated to some given normal pressure, the other may be sheared and a new sample inserted in the box.

Continuous Welded Rail Study Begun by the A.R.E.A.

Contents in Brief—A study of welded rail joints has been begun by the American Railway Engineering Association to determine what results can be obtained using available commercial processes. The preliminary tests are outlined briefly together with the test committee's observations concerning the results obtained.

IN CONTINUATION of its comprehensive investigation of rails and rail joints, a study of continuous welded rails was begun in 1937 by the American Railway Engineering Association, in cooperation with the University of Illinois (Engineering Experiment Station), and the first progress report has now been issued in Bulletin 411 of the association. The study covers comparisons between a welded and a bolted joint, and between the weld and the adjacent solid rail, but it is stated in the report that the study is not far enough advanced for any definite conclusions to be drawn. Field work has only been started. Laboratory investigation includes the following: (1) etch tests to locate defects; (2) hardness, crystalline structure and chemical composition of weld, heat zone and rail; (3) mechanical tests and rolling-load fatigue tests. At present, 104 test rails have been supplied, welded by five different processes: two forms of gas fusion welds, Thermit weld, electric-flash butt weld, and gas-heated pressure butt weld.



Horizontal etching of welded rail joints. These etchings were made of sections 3/16 in. below the tread. Sections *A* and *B* are gas fusion welds by processes A and B respectively. Section *C* is a Thermit weld; *D*, electric flash pressure weld; *E*, gas-heated pressure weld.

Etch tests show evidences of inclusions, laps, fiber bending and crack-like marks. How much damage these do is uncertain, although actual cracks act as nuclei for the spread of fissures or other fatigue cracks. But obviously, says the report, the macro-structure of the steel in and near the weld has been changed from that in the rail. Etched sections taken $\frac{3}{16}$ in. below the rail head, as given in the accompanying cut, show distinct characteristics for the different types of welds. In the Rockwell "C" hardness test, the average numbers found are as given in the table herewith.

Specimens given for tension, tension-impact and fatigue tests are said to indicate for all the joints a rather wide variation of the quality of material in the joint. None of this joint metal reached the full value of the rail steel, except as to the tension-impact values in electric-flash welds and reduction of area in gas-heated pressure welds, although the electric-flash welds nearly reached the tensile strength of the rail steel. In bend tests, head down, solid rails carried 225,000 lb. and 300,000 lb. before fracture. Welded joints gave the following results: gas fusion welds (Process A), 124,200 and 168,500 lb.; gas fusion welds (Process B), 79,000 and 140,000 lb.; Thermit welds, 193,500 and 231,500 lb.; electric-flash welds, 315,000 lb.; gas-heated pressure welds, 217,600 and 239,200 lb.

Rolling-load test

In the rolling-load tests, under repeated wheel loads, the limiting number of loads was taken as 2,000,000, or 20 times the assumed number of 40,000 lb. loads during the passage of 300,000,000 tons of traffic over the rails. Two gas-fusion welds and two Thermit welds failed to stand even one cycle, although a third Thermit joint succeeded. Of three electric-flash joints, two failed by cracking while the third sustained 2,000,000 cycles of loading. Of three gas-heated pressure welds, two failed under less than one cycle, while the other stood without fracture.

That welded joints are not to be judged by the rolling-load test alone is pointed out in the report. Other factors are the lack of homogeneity

ROCKWELL "C" HARDNESS IN WELDED RAIL JOINTS

Weld	Wt. of Rail	Rockwell Numbers: Rail	Heat Zone	Weld
Gas, fusion Process A	112 lb.	22	21	22
Gas, fusion Process B	131 lb.	23	26	31
Thermit	112 lb.	23	24	22
Thermit	131 lb.	22	27	25
Electric flash	131 lb.	23	28	30
Gas-heated	112 lb.	23	20	25

shown by tests and microscopic examination, and the variation of strength, ductility and toughness as shown by tests of specimens: "It must also be remembered that all the joints tested in the rolling-load machine were made with the knowledge that they were test joints, and this might have made them [the fabricators] make them either better or poorer than the average joint welded under service conditions. * * * In all considerations of welds, the occasional occurrence of a poor weld must be recognized. There is at present no reliable non-destructive test for poor welds, and there are very few if any data on the probable frequency of occurrence of poor welds in rail joints. These considerations, together with considerations of the relative seriousness of failure of joint bars and of welded joints in rails, must be factors in deciding whether or not to use welded rail joints in track."

Effect of understress

An item of interest is that a welded joint under 75,000-lb. wheel load in the rolling-load test withstood more repetitions of load than a joint under 60,000-lb. load. The report says in explanation: "This may be due to the fact that the joint had previously been subjected to 2,000,000 cycles of a 40,000-lb. load without fracture. This seems to indicate that welded joints may be strengthened by being subjected to many cycles of stress below the fatigue limit of the original material. This phenomenon of strengthening of metals by repeated understress has been known for several years, and repeated understress is just what rail joints receive in service, together with a rather rare overstress."

The report was prepared by Prof. H. F. Moore, Prof. Howard R. Thomas and Asst. Prof. Ralph E. Cramer, all of the staff of the University of Illinois, who are respectively, head of the Joint Investigation of Welded Rails, engineer of tests and metallurgist.

Prof. Moore, in his foreword, cautions against drawing definite conclusions from this progress report. It has been necessary, he states, "to report tentative values of fatigue strength, drop-test values and bend-test values for continuous welded rail on the basis of a very few tests. This necessity in the case of fatigue tests is one faced by all investigators of fatigue properties of full-sized members. It is most strongly urged that these results be regarded as tentative, and if they are so regarded, it is believed that the publication of them at this time will be of value."

Precast Spillway-Ditch Lining

DRAINAGE STRUCTURES along the Angelus Crest highway in Southern California have to provide for heavy runoff over deep fills. Slopes are so steep that lining of some sort is necessary to prevent erosion of the spillway channels. These conditions were met effectively by the use of precast concrete slabs poured in a nearby parking area and lowered to place with the aid of a power winch and a car constructed to operate on a track in the spillway trench excavation.

The slabs for spillway bottom and slides are the same size, namely, 1½ x 3 ft. with a thickness of 4 in. The forms used were 4 x 4-in. timbers staked to the ground. Chamfered strips were nailed to the forms to provide a V-shaped groove on all edges into which grout could later be poured to form a lock. Seven men and a foreman could cast about 80 such slabs per day.

Fig. 1. Spillway ditch down a 65 per cent slope, paved to prevent erosion.

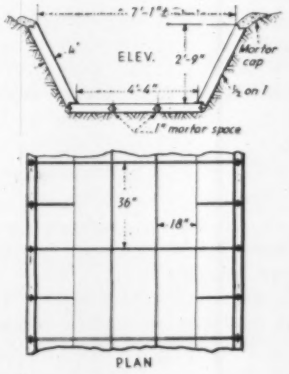


Fig. 2. Details of precast slabs used in spillway lining.

On the spillway bottom the slabs were laid lengthwise; on the sides they were stood on end. In all cases space was left for joints to receive grout. The crew of 7 men and foreman could place about 30 slabs per day.

On the spillway shown in the accompanying picture the average slope was 65 per cent. In order to provide occasional anchorages and at the same time to avoid risk from construction joints, a concrete anchor of 9 x 12-in. section extending across the bottom and up the sides of the trench, was put in at the end of each day's run.

The spillways were designed and built by the division of highways, California department of public works.

A QUESTION TO ANSWER:

Should WPA Continue in Construction?

Yes—says F. C. Harrington

Commissioner, Work Projects Administration, Washington, D. C.

WITH REGARD to unemployment the American people are overwhelmingly committed to the proposition that work and wages on socially useful improvements and services are far preferable to a dole. The federal work program is the concrete expression of this belief. Through a partnership arrangement with states and local communities who sponsor and help finance work projects for their own unemployed, the WPA in the past year provided socially useful work for an average of 3,000,000 needy unemployed. In so doing, it vastly enriched the communities, poured purchasing power into the economic stream, and conserved our human resources against the day when they will be needed in private industry.

In operating this program every effort has been exerted to cooperate with private industry, not to compete with it. The unemployed, for example, could have been set to work producing goods for themselves or for sale in the open market. Instead, except in one case, that of women's sewing and canning rooms whose products are distributed free to relief families, they were put to work on public projects—creating community improvements and social services.

No private competition

The WPA wage scale is an additional safeguard against competition with private industry. The WPA does not pay its workers normal wages, but pays them so-called security wages which are about half the corresponding earnings in private industry.

This prevents the WPA from bidding workers away from private industry and creating an artificial labor shortage. WPA workers are also compelled to accept any jobs offered in private industry, except when they are offered on manifestly unreasonable terms. Furthermore, the legislation recently enacted, appropriating funds for the WPA for the twelve months beginning July 1, 1939, contained a provision requiring that all Work Projects workers shall be required to work 130 hours per month to earn the security wage. This is a salutary requirement which will provide a further safeguard against competition by the WPA with private industry.

As much contract work as ever

Despite all these precautions, there are certain sections of business that still complain of WPA competition. Among those who have most frequently expressed this complaint are the construction contractors. According to some of their spokesmen every dollar of WPA work is a dollar taken away from contract work.

It is true that a large percentage of WPA work is in the field of construction. This, however, is not enough to establish the case for WPA competition with contractors. Let us look at the record. Recently the Associated General Contractors, Inc., appeared before the House Appropriations Committee to testify on the relief bill. They submitted detailed figures on private and public construction over a period of years. What do these figures show? They show that in the boom period 1925 to 1929 public contract construction averaged $2,292,000,000 a year. During the three years 1936 to 1938, inclusive, when the WPA was in operation, public contract construction averaged $2,168,000,000. In other words, private contractors are getting practically as much public construction as they got in the boom years before the depression of 1929.

The contractors' figures do show that there has been a very serious curtailment in private construction. But the WPA does not build private houses, factories or office buildings. It does not interfere with private construction.

WPA provides jobs more quickly

Our experience during the last six years shows that while contract public works have a definite place in a recovery program they cannot be relied upon as the principal means of dealing with mass unemployment. They do not provide employment either as cheaply or as quickly as the WPA method of government-operated projects.

Nor does such contract employment reach the classes that are most desperately in need of help and in the seasons when they most need that help. Thus our figures show that WPA construction work tends to be contra-seasonal. When private contractors lay off workers, we take them on; when private contractors ask for workers, we lay them off. It is also a fact that the contract public

OPPOSING VIEWS

In these three pages is presented a pro and con discussion of a vital national problem that is of particular interest to the construction industry. The authors, Col. F. C. Harrington, WPA Commissioner, and W. A. Klinger, well-known contractor, have written for and against WPA in construction in a manner that commands respect and with the express purpose of stimulating thoughtful consideration of both sides of this controversial question. If after careful reading and reflection the reader can agree with one or the other, opportunity is offered for recording his vote on a return mailing card. Results will be published as a matter of general interest. Should WPA Continue in Construction? What do you think?

works program voted last year has yet to reach its peak of employment. On the other hand the WPA can reach any reasonable peak of employment within a few weeks after Congress appropriates the funds.

Reasons for force account work

There has been some misunderstanding as to the reasons why the WPA carries on the bulk of its construction work by the force account method. This is principally due to two factors. The first and most important one is that, since the WPA program must be expanded and contracted to meet current unemployment conditions, it has to be conducted with sufficient flexibility to enable this to be done. Therefore, the rigidity that would result from the adoption of the contract method of construction is not suited to the character of the program. The second factor is that difficulty has been encountered in attempting to enforce requirements that contractors shall take labor from the relief rolls.

However, the WPA encourages sponsors of projects to enter into contracts in the largest degree possible. These contracts often provide that the contractor shall furnish supervision, equipment and materials and shall be the sponsor's representative on the job. The WPA then furnishes labor to work under the contractor's supervision. The use of this method has proven very satisfactory in many places and is being adopted in an increasing degree throughout the country.

It is entirely proper that contractors' organizations should carry on a campaign to increase the work and profits of their members. But in the presence of our staggering unemployment problem, it is necessary to put aside private interests and take a public view of the problem.

No—says W. A. Klinger

Contractor, Sioux City, Iowa

TO THE question, "Should we continue unemployment relief by WPA construction?" the answer of the construction industry is emphatically "No." In this answer it is acting not only in self-preservation, but in the public interest.

Ever since the first CWA appropriation, through the years of increased appropriations for FERA and WPA, the general contractors of the nation have been pointing out the fallacy and waste of that form of relief expenditures. It is true that CWA (the leaf-raking program) met an emergency. Men had to have sustenance, and some form of work for that sustenance seemed the best immediate form of relief. But as the program went on year after year, with increasing appropriations, it lost its emergency characteristic and seemingly has become a fixed policy, a permanent government construction agency, deeply rooted, implemented with organization, personnel and construction equipment, more and more ambitious and more and more determined to do all public construction work on a socialized basis. Obviously, then, we are not discussing the merits of a temporary relief measure, but those of a fixed government policy.

The construction industry wants it clearly understood that it recognizes the problem of relief of the unemployed. The unemployed must be taken care of, preferably by employment, but solution of the entire problem can only come by employment in private industry.

It is now generally recognized that the billions spent on WPA have in no way helped actual recovery. No pump has been primed, only a lot of water spilled. The construction industry maintains that sound recovery has actually been retarded by continued WPA activity in construction.

Economists are unanimous in the opinion that recovery in America cannot come until the capital goods industries recover. The major and most depressed capital goods industry is construction. It is the key to recovery. In normal times it filled more pay envelopes with more dollars than any other industry. It employed one out of every seven employables in America. It was the nation's greatest single employment force, and its greatest investment source. Its contribution to the national income, reaching as high as 19 per cent was greater than that of any other single industry.

When depression came, construction at once became the greatest single contributor to unemployment. From a normal of ten and a half million employees it dropped to less than two and a half million, and has not recovered beyond four million. It remains the most depressed of the major industries. If construction could step up its present three to four billion dollar annual volume to its former ten to thirteen billion dollar mark, the nation's reemployment problem would be largely solved and sound recovery instituted. The biggest single barrier to such a recovery is government competition in the form of increased construction activity through WPA.

Public contract volume small

Contrary to popular belief, the actual fact is that public construction by the contract system through the regular channels of the industry is only a fraction of pre-depression years. Municipalities, counties and states have practically stopped letting contracts for construction projects unless the federal government pays the bill. In every community in the United States there is WPA activity on some imitation construction operations. In every community high pressure salesmen, WPA employees, are selling the WPA way of doing construction to politicians, county

Mark and Mail Your Answer

NO POSTAGE NECESSARY

Should WPA Continue in the Field of Construction?

WHAT DO YOU THINK?

☐ Yes, with Col. Harrington

☐ No, with Mr. Klinger

Check your classification:

General Contractor ☐ ; Sub-Contractor ☐ ; Consulting Engineer ☐ ; Federal or State Engineer ☐ ; City or County Engineer ☐ ; Teacher ☐ ; Other ☐ .

Signature (if you wish)

officials, city councils. More and more the nation, once highly resentful of this organized loafing, has become tolerant of it; more and more the local politician, the Council of Mayors, the Conference of Governors, finding in WPA an opportunity to relieve their own charity loads, have become the strong advocates of increasing appropriations, and Congressmen, bent on re-election, cock an ear to the voting strength of WPA and, without thinking the problem through to its economic conclusion, vote the money. And each dollar appropriated retards construction recovery and, as economists agree, retards general recovery.

WPA costs are high

No group of politicians in any governmental unit will, on their own volition, publish cost figures on WPA work. But some of the costs have become public. Labor costs vary from 100 to 400 per cent more than on contract work. See the records of the recent suddenly suspended Congressional investigation. The need for public improvements in America will never be satisfied. We have expended enough money the WPA way to have had the greatest era of public works construction in the history of mankind. We have spent the money, piled up the national debt, and have little or nothing to show for it. Economists agree that the same amount of money spent through private industry under the contract system would have produced equal employment and a tremendous addition to our national wealth in needed public improvements.

The brief Congressional investigation also revealed the fact that WPA actually competes with private industry for employees, takes them away from private industry. By actual count, seven out of eight men employed on one large New York job (at the World's Fair) were not from relief rolls. Generally WPA personnel is not fitted to skilled mechanics' work. It fits no better in construction than it would in any other industry. Neither is there any more reason for having it in construction than in automobiles, textiles or cosmetics.

The attitude of men on WPA is definitely bad. The desire to work, to achieve is entirely lacking. The attitude distinctly is that the government owes them a living, and their purpose is to get it as easily as possible. They feel they own their jobs, and do not have to merit them. Contractors have found that a period on WPA has entirely changed the attitude of once good workmen. "Shovel leaning" is permanently dissipating the energies of a large group of American citizens.

Politics in WPA under the Hopkins' regime is such a well established fact that it need only be mentioned. The personnel has been in mental, economic and political slavery to such an extent that its political influence has furnished too great a balance of power and has too frequently been used for subversive purposes. Relief and politics should not be permitted to mix, but all politicians will continue to cater to the WPA vote, as long as WPA goes on.

The case against W.P.A.

WPA has been proven to be:

1. Extremely wasteful and uneconomic.
2. Bent on self-preservation.
3. Ruinous to the "morale" and "desire for accomplishment" of workmen.
4. A politically subversive force.
5. A violation of every concept of engineering and construction progress.
6. A devastating government-subsidized competitor of the construction industry.
7. A retardant to recovery by its socialization of the construction industry.

If not WPA, then what? The answer is simple:

A continuous PWA program of genuinely useful public works, costing no more and possibly less than WPA, erected by private industry under the contract system through the regular channels of the construction industry. The native raw materials of the construction industry are of small value while 85 to 90 per cent of all construction expenditures go to labor: Three and a half man-hours in the factory, mine or forest for each man-hour on the job. And so through all the capital goods industry would flow the impetus of such a program. Men put back on the jobs they were trained to perform. Back on private payrolls, producing as they normally should. America needs such a program of public works built to produce the most in permanent tangible wealth for the taxpayers' money. Let the construction industry undertake such a program. Let the contractors hire their own labor, no more, no less than they need. Let them get real work out of this labor. Let them restore the joy of accomplishment once inherent in the American workman.

Home relief for unemployed

Feed and shelter the balance of the unemployed on home relief, turning them back to their local governmental units, which previously took care of them. Let the federal government, if and when necessary, furnish financial assistance to such local units. Let these unemployed look for and take whatever employment they can get; encourage them to get off relief by making it easy to get back on relief when their sources of employment fail them.

Such a program is in trend with recovery. It offers employment equal to the present WPA set-up. It puts that employment back into private industry where it belongs. It would re-establish the American system of free enterprise in construction.

I would be unfair to Col. F. C. Harrington if I failed to express admiration for his recent attitude on WPA legislation and particularly during the WPA strike. Here his courage and firm purpose may have prevented a national calamity. But the WPA system, after many years' trial, is an avowed failure and must not be permitted to become a fixture in American economic and political life.

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Pressure Aqueduct for Boston

KARL R. KENNISON

Chief Engineer Metropolitan District Water Supply Commission, Boston

Contents in Brief *— To protect Quabbin Aqueduct water from contamination by surface flow into present open channels and grade-line aqueducts, an 18-mi. pressure aqueduct is being built from Wachusett Reservoir to the Boston metropolitan district. Better distribution pressures will be obtained. In ultimate development a rock-tunnel distributing loop encircling the district will further improve the supply. The new pressure aqueduct is unusual in consisting mainly of large size precast concrete pipe.*

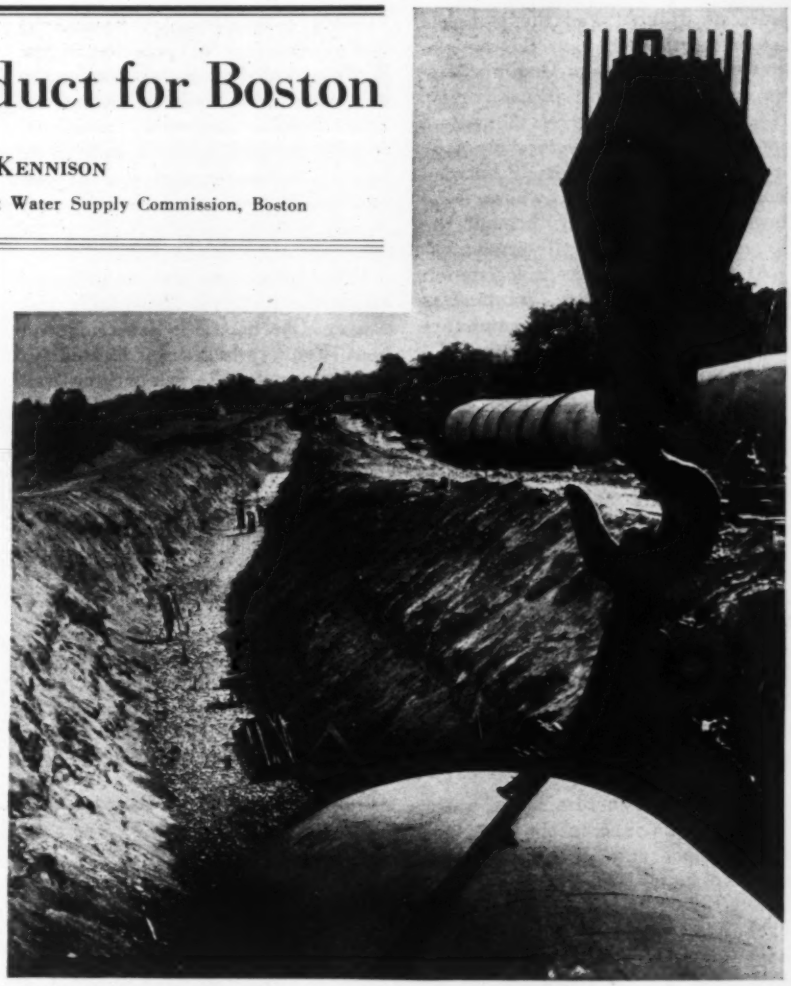


Fig. 1. Pipe-laying work on Boston's new pressure aqueduct is in active progress.

TO SAFEGUARD AND IMPROVE Boston's water supply an 18-mi. pressure aqueduct is being built from the Wachusett Aqueduct to the eastern end of the existing Weston Aqueduct. Planned by the late Frank E. Winsor, until recently chief engineer of the Metropolitan District Water Supply Commission, and the writer, the aqueduct is intended to bypass the old and now seriously polluted Sudbury and Cochituate supplies and carry the new Quabbin Aqueduct supply of Swift and Ware river water together with Wachusett Reservoir water directly to the district without contamination. In doing so it will also increase the delivery head by eliminating the loss of head in the present open-channel flow from Wachusett to Sudbury, and the drop at the present Sudbury Dam. Much pumping will be eliminated. In the ultimate development of the project a deep rock-tunnel loop extending around the district is to supply the entire distribution system at various feeder points, which will save 95 per cent of present pumpage.

To avoid infiltration of groundwater the new aqueduct was planned as a pressure line, operating under heads from 20 to 220 ft. at present and some 30 ft. higher (west of the high-level reservoir) at a later stage, when the aqueduct may be connected direct to a new outlet from Wachusett Reservoir.

The new aqueduct is being built of large size concrete pipe except for a three-mile section of tunnel under Sudbury Reservoir. Precast concrete pipe was adopted as cheaper than pressure conduit built in place although topographic conditions were well adapted to economical construction of either type. The initial capacity is to be 200 mgd with provision for 300 mgd by adding a second and parallel line east of the tunnel under Sudbury Reservoir (ultimate capacity 300 mgd). Ultimately, when the loop aqueduct is completed, a pressure of 100 lb. will be possible throughout the low-service district by gravity delivery, and the high-service reservoir can also be supplied by gravity.

The new aqueduct is being constructed as a PWA project. It will supplement the Ware and Swift River additions to the present sources of supply which the Metropolitan District Water Supply Commission has been building since 1926.

The first step in the Ware-Swift program was the construction of a tunnel from the southerly end of Wachusett Reservoir to intercept the Ware River at Coldbrook. Its completion in 1931 made this source available to a limited extent pending the completion of more ample storage capacity. The second step, extension of the tunnel westerly to the Swift River, was substantially completed in 1935. The entire tunnel, known as Quabbin Aqueduct, is 24.6 mi. long. Its completion made it possible to obtain an additional emergency supply from the east branch of the Swift River at the point where it passes the tunnel intake. However, the last four years have not been

years of drought and the complete use of the tunnel awaits the completion of the third step, Quabbin Reservoir, in the Swift River valley. This reservoir will store the waters not only from the tributary drainage area of the Swift River itself, but also from the Ware River, whose flood flows can be diverted through the tunnel into Quabbin Reservoir.

At the time the recent legislation authorizing the PWA grants was passed, the water supply commission had spent a net total of about $41,300,000 of the total $65,000,000 originally appropriated for the Ware-Swift development. Of the remaining $23,700,000, about $11,600,000 will be required to complete this development, leaving about $12,000,000 surplus for aqueducts.

The legislature of 1938 restricted expenditure prior to Nov. 30, 1941, to slightly more than $17,000,000. After completion of existing contracts, settlement of real estate and diversion damage commitments, etc., this left less than $8,800,000 available for new PWA construction.

Contamination hazards

Excessive and increasing exposure to pollution is inherent in the present aqueduct and distribution system. The supply from the main Wachusett Reservoir is discharged from Wachusett Aqueduct via an open channel into the relatively small Sudbury Reservoir on the shores of which are Marlborough and Southborough, which, in spite of all precautions, contribute an increasing amount of pollution. Further contamination may occur in the aqueducts below the reservoir.

Weston Aqueduct, an 11.3-mi. grade-line aqueduct completed in 1903 and in fairly good condition, has a capacity of about 300 mgd, but is throttled at two inverted siphons across the Sudbury River valley and Happy Hollow, aggregating 4,725 ft. in length; this obtacle is now being removed by the construction of an additional line of pipe in each siphon. Its capacity to deliver water to the district is limited to about 130 mgd through four 48 to 60-in. supply mains and can only be increased by the multiplication of these expensive surface mains through heavily populated areas. However, two of these supply mains are of steel-plate construction and capable of taking a considerably increased head. Unfortunately it is necessary, because of the present lack of capacity in the Weston Aqueduct supply mains, to use also the Sudbury Aqueduct. This 7½-mi. grade-line aqueduct, completed in 1878, is not sufficiently tight to insure the exclusion of polluted groundwater.

Other sources of pollution

Other present sources of pollution are at the low-level distributing reservoirs, Chestnut Hill Reservoir and Spot Pond, which are located in densely populated areas and not well enough protected. The former can not be eliminated from regular use until a deep rock tunnel is built to Chestnut Hill to supplement the Weston Aqueduct supply lines. Such a tunnel has been authorized, but the legislative restrictions on the rate of expenditure and PWA restrictions on time of completion made it necessary to postpone it for the present. However, when this tunnel is completed in the near future it will not only make possible the elimination of Chestnut Hill Reservoir from regular use by the substitution of equivalent adequate storage at higher levels, but also will do away with the necessity for the Southern High Service pumping, now done from Chestnut Hill Reservoir.

New distribution loop

This proposed tunnel to Chestnut Hill is part of a deep rock-tunnel distribution loop extending under Boston and all other principal centers of distribution by which a substantial increase in pressure can be made available throughout the district so that pumping to the Northern High Service from Spot Pond can also be discontinued. Although this gravity delivery to the Northern High Service is something for the future, the regular use of Spot Pond can be discontinued at an early date—as soon as the additional head on the Weston Aqueduct supply mains increases their rate of delivery to the Spot Pond pumps, and as soon as enlargement of reservoir capacity at the higher levels of the Northern High Service allows a sufficiently flexible pumping schedule to permit the Weston Aqueduct supply mains

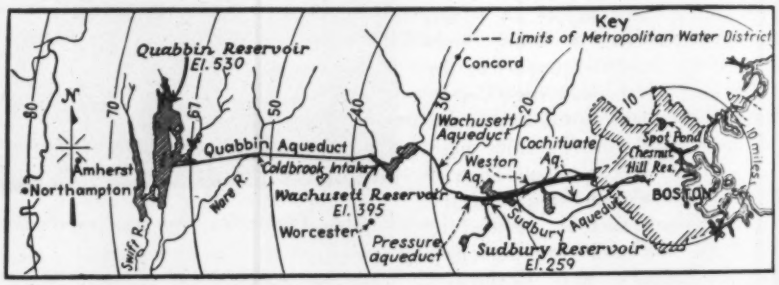


Fig. 2. Supply from the Swift and Ware rivers through the new Quabbin Aqueduct will reach Boston without contamination by way of a new pressure pipe aqueduct from Wachusett Reservoir to the boundary of the metropolitan district.

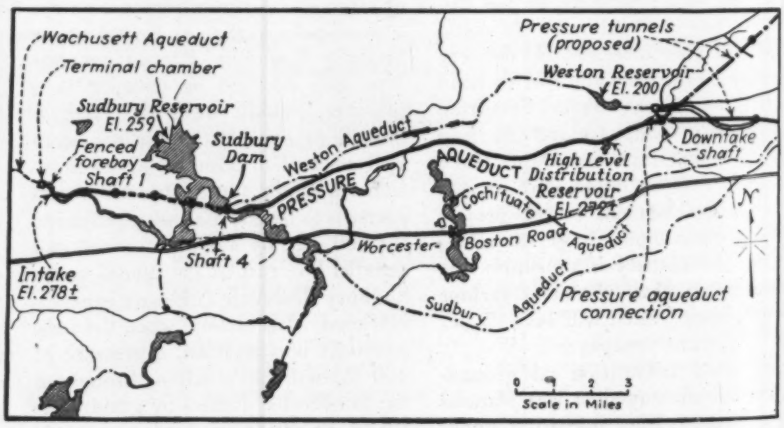


Fig. 3. The pressure aqueduct consists of two miles of 12½-ft. concrete pipe, three miles of 14-ft. tunnel passing under Sudbury Reservoir, then 12½ miles of 11½-ft. pipe. A half mile of 7-ft. pipe will connect with the Weston Aqueduct.

to discharge at practically their full capacity at all times.

As a result of the 1938 legislation, a PWA grant of nearly $7,000,000 was obtained to match the state's contribution of about $8,800,000, previously described, so that about $15,500,000 worth of construction is being undertaken at a rapid rate by the Metropolitan District Water Supply Commission. This covers principally the construction of a new pressure aqueduct in lieu of the present grade-line aqueducts, and includes nearly $2,000,000 for clearing Quabbin Reservoir site and other work of completing the Ware-Swift project.

The new pressure aqueduct starts at the east terminal chamber of the Wachusett Aqueduct where a small protected forebay can serve as an equalizing basin between the grade-line and the pressure aqueduct. The pressure aqueduct then extends in 12-ft. 6-in. diameter cut-and-cover construction for a distance of 2 mi. to a downtake shaft, then in 14-ft. tunnel under Sudbury Reservoir for 3 mi., then in 11-ft. 6-in. cut-and-cover construction for a distance of 12½ mi. to a downtake shaft just west of the Charles River and outside the thickly populated water district.

This downtake shaft will lead to the deep rock tunnel at Chestnut Hill to be constructed in the near future as above described and also to the future loop distribution tunnel. Near the eastern end of the new pressure aqueduct, at the Charles River, a connection consisting of a little over 2,000 ft. of 7-ft. cut-and-cover aqueduct is being built to connect with the existing Weston Aqueduct supply mains near the Weston Aqueduct terminal chamber; and by this means the increased head will be made available on the present mains.

The pressure aqueduct not only eliminates the regular use of the present grade-line aqueducts, but also by-passes Sudbury Reservoir with its populated shores, passing this reservoir at a hydraulic grade 15 ft. above the reservoir flow line. The grade at the Wachusett Aqueduct terminal equalizing basin, where the pressure aqueduct will take the water, is 278 ft. above mean low tide. The gradient which limits the high points of the pressure aqueduct has been established so as to permit the aqueduct to be used in an emergency to draw directly from Sudbury Reservoir. In such an emergency, the grade in the future tunnel loop would be lowered about 15 ft., and existing reservoirs on the Southern High Service at this lower grade will again function. Advantage is also being taken of an existing pond adjacent to the new high level distributing reservoir for such future emergency operation at slightly reduced gradient.

The present construction includes a new high-level distributing reservoir which will ride on the aqueduct at El. 272 and which will be matched by a similar reservoir a few feet lower northeasterly of the district, constructed by enlarging the Fells Reservoir of the Northern High Service.

Design and construction of the new pressure aqueduct is the work of the Metropolitan District Water Supply Commission, Eugene C. Hultman, chairman, Thomas C. Lavelle, Edward J. Kelley and R. Nelson Molt, secretary. Karl R. Kennison is chief engineer, with Stanley M. Dore as assistant chief engineer and Charles L. Coburn, principal designing engineer and Walton H. Sears as mechanical engineer. Field work is in charge of Fred W. Gow and Coleman C. McCully as division engineers. Resident engineers on individual contract sections are: P. M. Putnam, D. K. Sampson, D. S. McLean, C. W. Smith, J. J. Vertic, R. W. Moir, and R. J. Fryar.

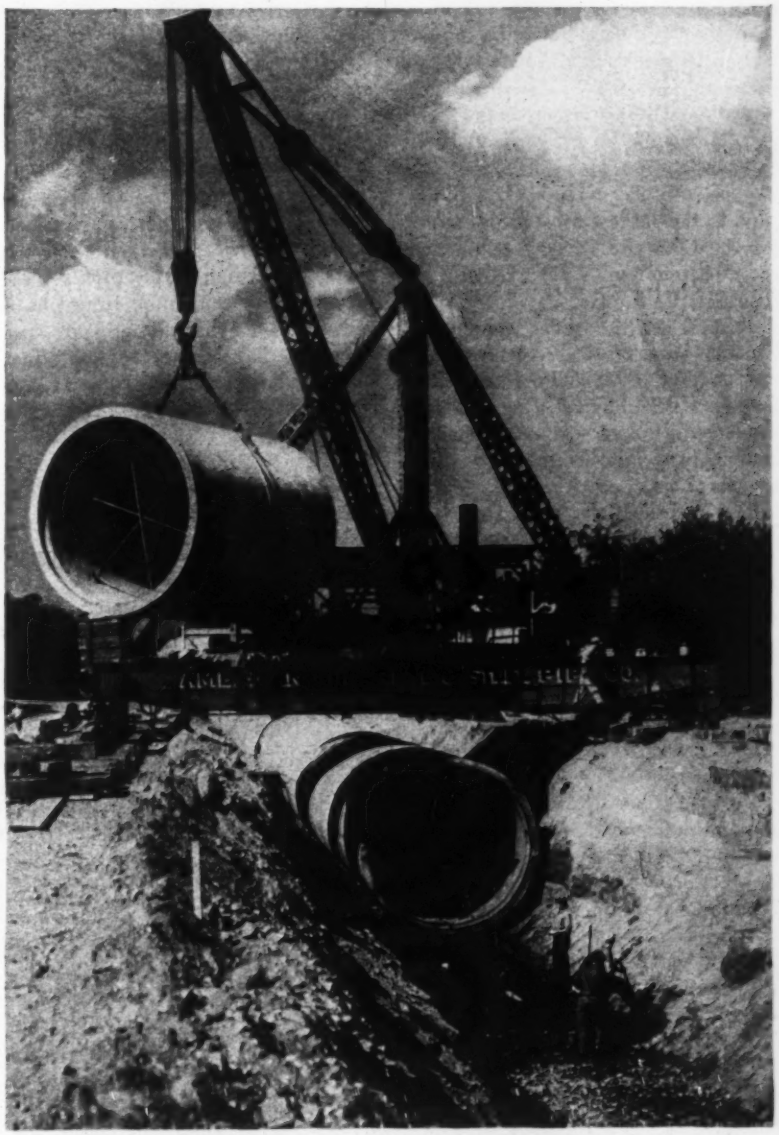


Fig. 4. On one section pipe is laid with a gantry derrick spanning the trench and moving forward on rails. It was built for the Colorado River Aqueduct.

Making Large Aqueduct Pipe

Contents in Brief—Large-scale production of heavy concrete pipe in sizes up to 12½-ft. diameter is the main feature of the construction of the 18-mile pressure aqueduct from Wachusett Reservoir to Boston. All-welded steel shells and reinforcement cages are produced to accurate dimensions and tested under hydraulic pressure. Pipe casting is aided by a rotating distributor, external vibrators and spading. The pipe is laid by gantry crane, by derrick car and by caterpillar-tread cranes.

MAKING and laying mammoth concrete pipe on a manufacturing scale is the outstanding operation in the construction of the Boston Metropolitan District's new pressure aqueduct. The project includes 2 mi. of 12½-ft. pipe, 3 mi. of 14-ft. rock tunnel, 12½ mi. of 11½-ft. pipe, and about ½ mi. of 7-ft. pipe. The 12½-ft. pipe is the largest ever made except for the Colorado River Aqueduct of the Metropolitan Water District of Southern California.

Because of the great amount of concrete pipe work involved in the undertaking (80,000 lin. ft. or 5,250 lengths of 12 and 16 ft.) an elaborate pipe-making plant was established at Natick, near mid-length of the line, by the Lock Joint Pipe Co., contractor for all of the pipe. This company sublet the fabrication of the steel structure of the pipe to the American Concrete & Steel Pipe Co., and for convenience the steel fabricating plant was erected immediately alongside the pipe-casting plant. The progress of the entire job depends on smooth and regular production at this manufacturing yard. All operations are necessarily keyed to schedule performance, as PWA regulations require completion by next July.

Despite its heavy weight, about 50 tons per 16-ft. length, the 11½-ft. pipe is cast complete at the Natick plant in 16-ft. lengths and is trucked to the point of laying by low-body trailer trucks operating over the regular public roads, and over delivery roads constructed along the aqueduct line between the public roads. For the upstream section of the aqueduct, built of 12½-ft. pipe in 12-ft. lengths, the pipe is cast in a second yard at Southborough, near the point of laying, the steel assembly being trucked in from the Natick plant. The completed pipe lengths are trucked over adjacent delivery roads to the points of laying.

Precast pipe was adopted for economy and tightness. To assure a firmly articulated and tight line, joints were required to have metal-to-metal bearing contact and calked fiber-filled lead gaskets to seal the joint. The design of the pipe is proportioned for maximum future head as well as for backfill pressure and the strength necessary for handling. For durability a strong concrete was specified. The joints were required to fit within a tolerance of 1/32 in. on the diameter, to assure load transfer without throwing undue load on the gasket.

Steel fabrication and assembly

Construction of the steel assembly for the pipe involves the following sequence of operations: shaping, welding and sizing the joint rings; assembling the steel sheets; curving and welding the shell; testing the shell for strength and tightness under hydrostatic pressure at a shell stress of 23,000 lb. per sq.in.; welding the joint rings to the shell; and wrapping the spirals and welding them in place.

The plant is laid out for a production rate of about 35 pipe assemblies per day, a slight excess over the pipe-casting capacity. It includes a bending shop for the pipe rings, a hydraulic press building in which the rings are stretched about 1 in. in diameter, bringing them to circular form and true size, a sheet-welding plant, and an assembly shop in which the shells are rolled and welded, the joint rings welded into place, the spirals wrapped and welded, and the hydrostatic test completed. This building also provides storage space for finished shell assemblies ready for delivery to the casting yard.

The spigot is made of a rolled special cross-section requiring no machining. These sections are cut to length, scarfed, rolled to circular shape, and joined into a ring by welding. The bell is made from 5/16-in. plate 10 or 10½ in. wide. After the butt welds are chipped to remove excess metal, the rings are passed through flanging rolls to bend in the edge which is later welded to the shell. Finally they are stretched to exact size by an eight-segment hydraulic press which expands the ring by about 3½ in. in circumference and produces true size and circular form so that the rings will match within the tolerance specified.

The shells are welded up of sheets about 4 ft. wide and 12 or 16 ft. long, varying in thickness from 10 gage to 9/32 in.; nine or ten such sheets (according to size of pipe) are automatically welded together along their longitudinal edges to form a sheet wide enough for the entire shell, or 36 to 40 ft. long. The sheet moves forward on tracks to the shell bending rolls, where the plate is curved to form the shell cylinder; a support which holds the top of the shell from sagging as it bends over the top of the rolls also serves as a carrier by which the rolled cylinder is carried forward to a welding mandrel. The closing seam is here butt-welded by hand. The finished shell, turned to vertical position, is lowered into a spigot joint ring against stops, and the ring is then arc-welded to the shell by hand. The bell is connected in the same way.

In the cage-winding machine the shell is held on the mandrel by expanding segments, the spacer bars are clamped to the cylinder to give the elliptical shape of the inner reinforcement spiral, which touches the shell on its minor axis (vertical axis

Fig. 1. The steel bell-and-spigot joint rings are rolled, then welded at the closing seam as here shown. Finally they are stretched in an hydraulic press to exact size and circular form so that they will fit properly.

Fig. 2. After automatic welding joins a number of sheets into one sheet long enough to form the complete pipe shell, the sheet is rolled into pipe form. Later the closing longitudinal seam is welded and the joint rings are welded on.

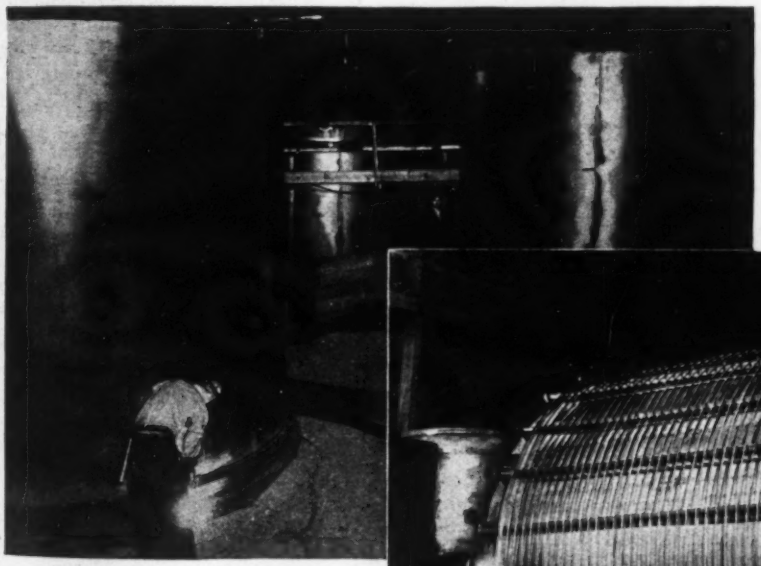


Fig. 3. In a special templet this shell is welded to the joint ring.

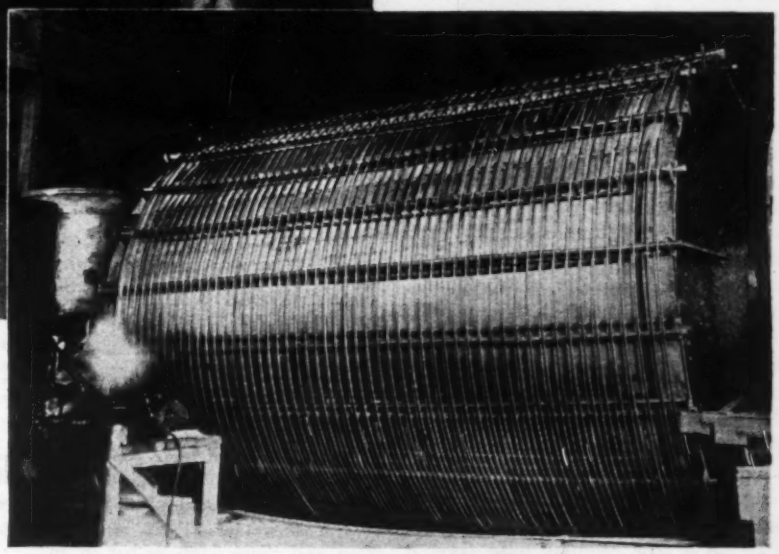


Fig. 4. Two reinforcing spirals, one elliptical and one circular, are wound on the pipe shell over spacer blocks and tied together by welded. to complete the pipe skeleton.

in the final position of the pipe) while on its major axis it is in the plane of the outer or circular spiral. The reinforcing rod, received in coils long enough to form one cage, is straightened and pre-curved as it feeds and when completely wound is welded at its ends to the joint rings. The outer or circular spiral is then wound midway between the windings of the inner spiral. When the reinforcing rod must be spliced it is welded by a resistance welder and stressed to 30,000 lb. per sq. in. before winding proceeds.

After completion of both spirals the entire steel assembly is removed from the mandrel by an overhead crane (using wide slings to prevent distortion of the spirals), and is stiffened by welding on longitudinal spacing bars. For this purpose the assembly is set on a horizontal roller bed for ready turning to facilitate welding of the bars. Finally the original spacing bars used for winding the spirals are removed for reuse in the winding machine.

Casting and curing pipe

The Natick casting yard, alongside the steel fabricating plant, has 72 pipe-casting positions in a straight line along a pouring track. Each position has a cast-iron base ring embedded to receive the pipe molds. The mixing plant, at one end of the casting yard, has a 500-bbl. main and 1,150-bbl. auxiliary cement bin, 75-ton sand and gravel bins, and two 2-yd. mixers fed by batchers. Aggregates are supplied by a sand and gravel plant set up by the contractor about 2 miles away, as no plant in the vicinity could supply the required amount of more than 1,000 tons of aggregates per day.

A rich concrete mix of low water content is used. Cement is about 1¾ to 2 bbl. per cu.yd., and water 5 to 5½ gal. per sack. The rich mixture and low water ratio assure both good workability and high strength. Test strengths of 5,000 lb. per sq. in. at 28 days are generally obtained and often exceeded; 4,000 lb. is required.

The regular casting schedule is for a production of 24 lengths per day of the 11½-ft. diameter pipe at the Natick plant and 5 lengths per day of the 12½-ft. pipe at the Southborough plant. To prepare for casting, the inner and outer forms and steel assembly are placed in vertical position on a true circular base ring, a true circular top ring which acts as a casting platform is clamped in position over the spigot end, and a revolving hopper with distributor spout leading out to the space between the forms is placed on top of the platform. The hopper is filled by a 2-yd. bottom-dump bucket brought by flat-car from the mixing plant and lifted by a locomotive crane; 10 to 12 bucketloads are required per pipe. Revolution of hopper and spout delivers the concrete evenly around the circumference of the pipe, and three motor-driven vibrators fastened to the outer form, supplemented by spading from the top, consolidate the concrete.

Moist steam (100 to 120 deg. F.) is fed into the inner form when casting is complete. The next morning the forms are removed, cleaned and set on a new base ring for casting another length. A canvas hood is placed over the pipe just stripped and steam curing continued for two days. After that the pipe is turned horizontal and rolled out on storage skids, where water-spray curing proceeds for twelve days. They are then ready for delivery to the laying contractor.

A series of radial jack struts is placed inside the pipe before it is turned to a horizontal position after steam curing to minimize deflections of the heavy pipe during handling and laying. These struts are removed a short time after the pipe is in place in the trench and jointed and given preliminary calking.

The rig for turning the pipe from vertical to horizontal position consists of a gantry that can be run over the standing pipe lengths, fitted with electric hoist drums. These lift the pipe by engaging trunnions on a broad steel collar clamped around the middle of the pipe.

The final operation on the pipe is to paint the exposed surfaces of the joint rings with aluminum paint. Transporting the pipe to the aqueduct line is done by 50-ton low-bed trailers pulled by 150-hp. diesel-powered truck tractors. Five delivery units make four to six trips each per day on an average haul of about 7 mi. At the point of delivery the pipe length is rolled from the trailer on skids, with the aid of tractors and winches.

Laying the pipe

Laying 12½-ft. pipe on the 2-mi. upper section is done by railway derrick car operating on a track built in the excavated trench. The pipe is rolled down a ramp by using a winch on a bulldozer and loaded on a car in front of the derrick. The derrick car pushes the pipe in front of it forward down into the trench to the advancing end of the finished pipeline and lowers the pipe to its prepared bed, at the same time entering the joint. Where the bottom of the trench is in rock, the bedding for the pipe is a concrete slab 12 ft. wide laid in advance of the pipelaying. About 9,700 ft. of 12½-ft. pipe is laid by B. A. Gardetto, Inc.

The 11½-ft. pipe east of the rock tunnel section is laid by several con-

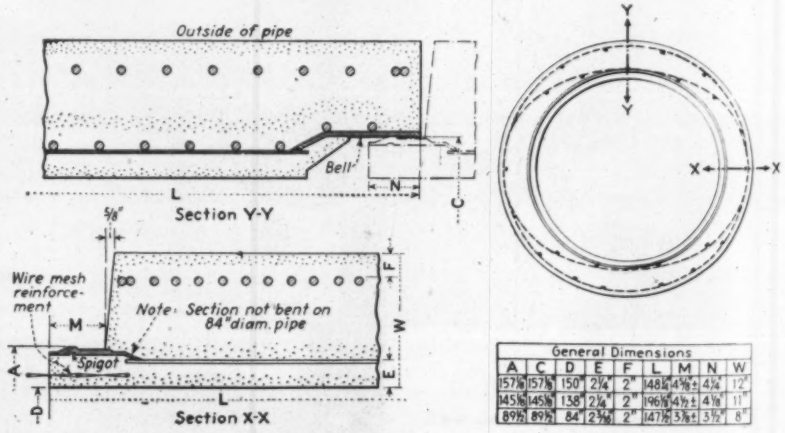


Fig. 5. Design of large concrete pressure pipe for the Boston Aqueduct includes a steel shell for watertightness, an elliptical and a circular reinforcing spiral, gasketed steel bell-and-spigot joint, and concrete encasement producing a wall thickness of 12 in. for 12½-ft. pipe. The actual product is showing concrete strengths often well above 5,000 lb. per sq. in.

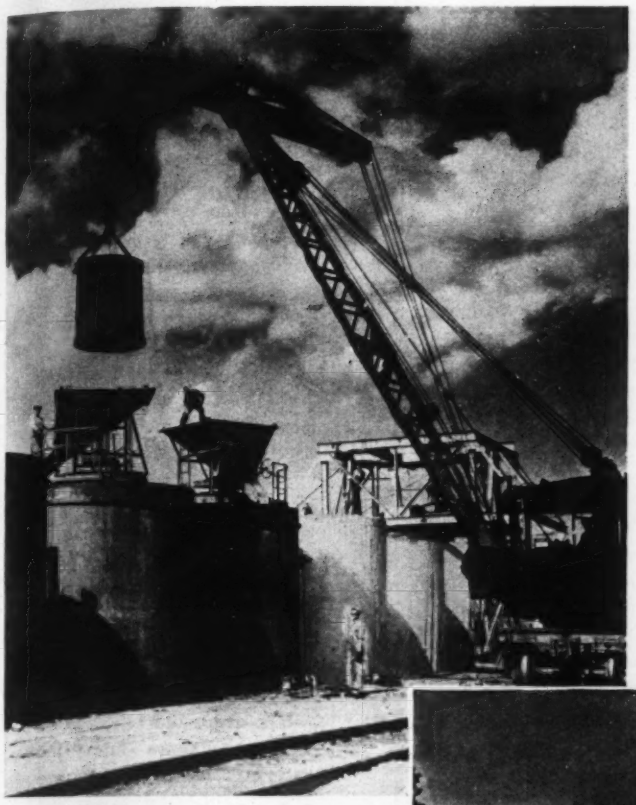


Fig. 6. Pouring concrete around the pipe skeleton is done with the aid of a rotary hopper and distributor chute, while vibrators clamped to the outside form consolidate the concrete and release entrapped air.

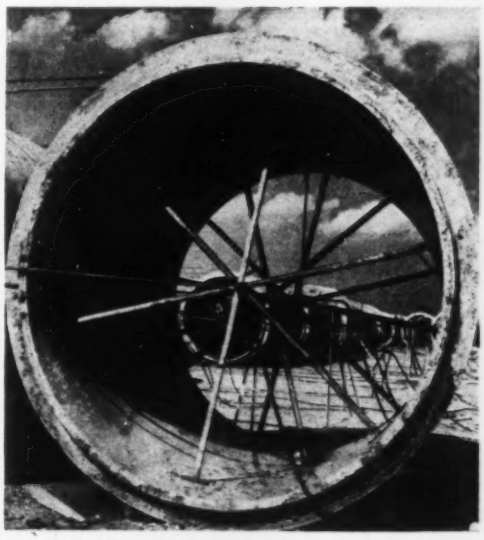


Fig. 7. After three-day steam curing the length of pipe, weighing 40 to 50 tons, is lifted by hoists hooked to trunnions on a clamping ring and turned to horizontal position for eleven days' spray curing.

Fig. 8. For rigid bedding, the pipe is cradled in concrete for about one quarter of its diameter.

tractors: B. A. Gardetto, Inc., 16,700 ft.; American Concrete & Steel Pipe Co., 35,800 ft.; and M. F. Gaddis, Inc., 15,400 ft. The last contractor also lays 2,300 ft. of 7-ft. pipe. The most interesting type of laying plant here is the American Concrete & Steel Pipe Co.'s gantry or traveling derrick platform used in similar pipe-laying on the Colorado River Aqueduct. The platform straddles the trench, running on tracks laid on the ground alongside or on berms in the sides of the trench, according to depth; a stiffleg derrick set on the platform lifts the pipe from the delivery skids alongside the trench and lowers it to place.

Some distance back of the leading end of the pipe, concrete packing is placed under the pipe and up the haunches to give rigid support on about 120 deg. of the pipe circumference. Above this haunching, the trench is backfilled with earth placed in layers.

The lead calking strip for each joint is sweated into a complete ring in the shop and is laid into the bell of the joint just before the spigot is inserted therein in the trench. As soon as the spigot is home in the bell the gasket is given a preliminary calking. Final calking (with air hammer) is done far enough back of the leading end of the work that the pipe is free of disturbance by the laying operations and has full support from the concrete haunching.

Manufacture of the pipe is in charge of W. R. Brend for the Lock Joint Pipe Co. Secs 1 and 3 of the pipe aqueduct are being built by B. A. Gardetto, Inc., in charge of Julius Abrams, general superintendent. Secs. 4 and 5 are being built by the American Concrete & Steel Pipe Co., with H. R. Bolton in charge of field construction. Sec. 6, built by M. F. Gaddis, Inc., is in charge of Edward R. Wintz, superintendent for the contractor.

Story of the Boston Broadside

M. N. BAKER
Associate Editor, Engineering News-Record (Retired)
Upper Montclair, N. J.

Contents in Brief—More than a century has elapsed since a meeting was called in Boston's famous Faneuil Hall demanding city ownership of a projected water system to succeed those built privately in 1652 and 1795. How the events before and after this meeting led the way to the present vast Metropolitan Water District are here outlined.

THE GREAT PRESSURE AQUEDUCT now being constructed by the Boston Metropolitan District to perfect its water supply development is in part the outcome of a broadside calling all good citizens of Boston to gather in Faneuil Hall, Aug. 16, 1836, to demand a supply of "Pure and Soft Water" procured "with your own means" and held "at your own disposal" rather than letting it be "shaped to the ends of private speculation."

Nearly two centuries earlier a few Boston householders had brought spring water to their homes, thus establishing the first waterworks in America. That was in 1652, only 32 years after the first settlers at Charleston, beset by failing springs, had moved to "Shawmut" or "Living Springs." Useful as were the wooden tank near Dock Square and pipes leading from it, they were soon outgrown and had become only a memory when, in 1795, the Aquedect Corporation brought in water from Jamaica Pond through four parallel lines of bored logs. The distribution system, bought decades later by the city, soon became inadequate. A large part of the growing town thus became dependent upon hard and sometimes scanty water obtained from shallow wells.

In 1825, three years after incorporation as a city, Boston took its first official steps toward an adequate water supply. Procrastination put off accomplishment for 23 years. From the outset there was a strong demand for public ownership. In 1826, Mayor Quincy declared: "If there be any privilege which a city ought to preserve, exclusively, in its own hands and under its own control, it is that of supplying itself with water." This assertion he supported with cogent reasoning.

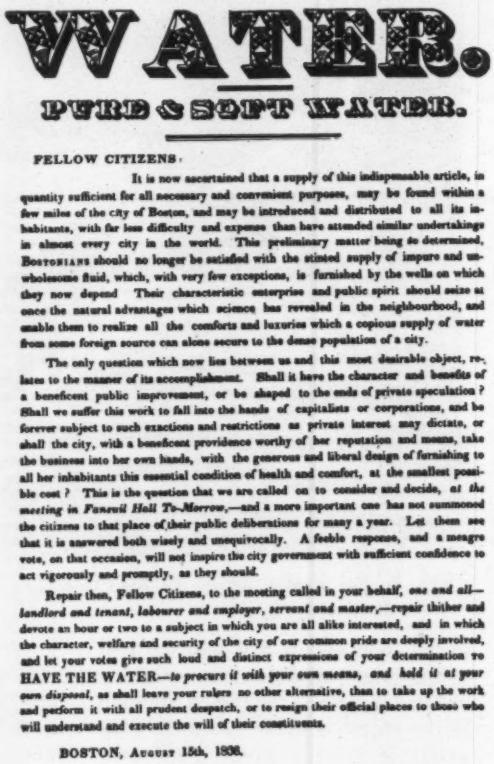
In an engineering report made in June, 1836, Robert H. Eddy advocated going far enough afield for water to make "projects of filtration" unnecessary. This doctrine has been followed religiously by Boston ever since that time.

On June 30, 1836, a water committee reported strongly against municipal ownership and advised the city council to endorse the incorporation of the Boston Hydraulic Co., organized to build waterworks. This led to the broadside of Aug. 15, to public meetings at Faneuil Hall, Aug. 16 and 22, and to a vote of 2,107 to 136 in favor of "pure and soft water" under city ownership. Despite this overwhelming public demand it was 20 years before engineers and contractors were authorized to make the dirt fly. That they did with such expedition that Oct. 25, 1848, was made a gala day to celebrate the introduction of water from Lake Cochituate. In his ode written for that occasion, James Russell Lowell declared that the lake had sped its waters "through strange dark ways—bringing four royal gifts—long life, health, peace and purity."

The ever increasing demands of a growing city led to the introduction of a supplementary supply through the Sudbury Aqueduct in 1878. Only 15 years later the growing needs of Boston and neighboring towns led to the creation of the Metropolitan Water District. Since then reservoirs and aqueducts extending ever westward to the Connecticut drainage area have been constructed in accordance with the doctrine of going afield for water not requiring filtration. Meanwhile the Cochituate supply of 1848 was placed in a reserve equivalent to abandonment. Now comes the pressure tunnel to eliminate the low-lying Sudbury reservoir and the exposed open channels in the eastern part of the aqueduct system.

In the galaxy of departed engineers who have taken part in the Boston water projects are Laommi Baldwin, John B. Jervis, E. S. Chesbrough, Joseph P. Davis, Alphonse Fteley, Desmond FitzGerald, Dexter Brackett, Frederic P. Stearns and Frank E. Winsor.

The citizens of Boston who rallied at Faneuil Hall a century ago in response to the Broadside here reproduced did better than they knew in demanding "pure and soft water" under public ownership.



WATER.

PURE & SOFT WATER.

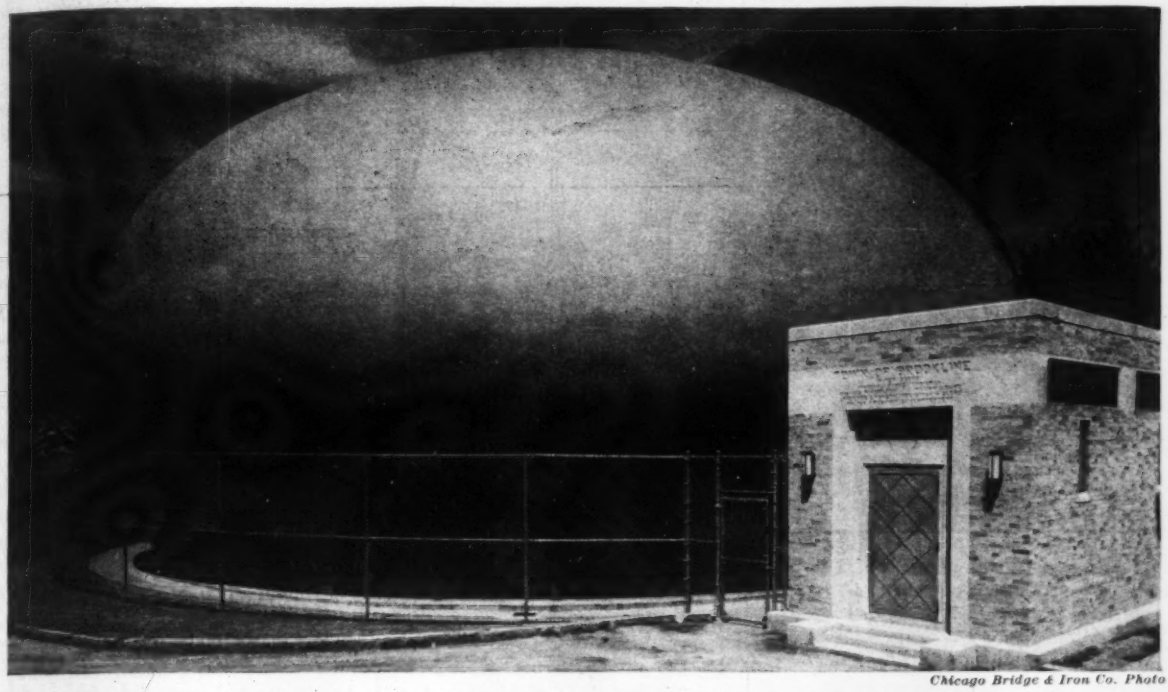
FELLOW CITIZENS.

It is now ascertained that a supply of this indispensable article, in quantity sufficient for all necessary and convenient purposes, may be found within a few miles of the city of Boston, and may be introduced and distributed to all its inhabitants, with far less difficulty and expense than have attended similar undertakings in almost every city in the world. This preliminary matter being so determined, BOSTONIANS should no longer be satisfied with the stinted supply of impure and unwholesome fluid, which, with very few exceptions, is furnished by the wells on which they now depend. Their characteristic enterprise and public spirit should seize at once the natural advantages which science has revealed in the neighbourhood, and enable them to realize all the comforts and luxuries which a copious supply of water from some foreign source can alone secure to the dense population of a city.

The only question which now lies between us and this most desirable object, relates to the manner of its accomplishment. Shall it have the character and benefits of a beneficent public improvement, or be shaped to the ends of private speculation? Shall we suffer this work to fall into the hands of capitalists or corporations, and be forever subject to such exactions and restrictions as private interest may dictate, or shall the city, with a beneficent providence worthy of her reputation and means, take the business into her own hands, with the generous and liberal design of furnishing to all her inhabitants this essential condition of health and comfort, at the smallest possible cost? This is the question that we are called on to consider and decide, *at the meeting in Faneuil Hall To-Morrow*,—and a more important one has not summoned the citizens to that place of their public deliberations for many a year. Let them see that it is answered both wisely and unequivocally. A feeble response, and a meagre vote, on that occasion, will not inspire the city government with sufficient confidence to act vigorously and promptly, as they should.

Repair then, Fellow Citizens, to the meeting called in your behalf, *one and all—landlord and tenant, labourer and employer, servant and master*,—repair thither and devote an hour or two to a subject in which you are all alike interested, and in which the character, welfare and security of the city of our common pride are deeply involved, and let your votes give such loud and distinct expressions of your determination to HAVE THE WATER—*to procure it with your own means, and hold it at your own disposal*, as shall leave your rulers no other alternative, than to take up the work and perform it with all prudent despatch, or to resign their official places to those who will understand and execute the will of their constituents.

BOSTON, August 15th, 1836.



Chicago Bridge & Iron Co. Photo

FIG. 1. SPHEROIDAL TANK AT BROOKLINE, MASS., THE FIRST OF ITS TYPE FOR WATER STORAGE.

Water Storage in a Spheroidal Tank

***Contents in Brief**—Something new in water storage facilities has made its appearance in Brookline, Mass., where a spheroidal tank has just been completed. This tank meets unusual esthetic standards combined with requirements for large storage within a relatively small range of head. The supporting structure, which carries vertical loads to the foundation and lends rigidity to the all welded tank, consists of a series of rib fins set vertically around the inside of the shell.*

FIRST OF ITS TYPE to be used for water storage, the spheroidal tank recently built at Brookline, Mass., ideally meets the special requirements that led to its adoption. The town was faced with the problem of securing one million gallons of storage within a head range of 30 ft., and at the same time providing a structure of esthetic merit in a high-value residential district. These conditions were met in the selection of a spheroidal-shaped tank similar to the type developed about 10 years ago for gasoline and oil storage purposes.

The tank is 90 ft. in diameter at its widest point (known as the "equator") and it stands 47 ft. above the ground. It is constructed of copper-bearing steel and all the plates and structural members were electrically butt-welded. The manufacturers of the tank, the Chicago Bridge & Iron Co., bettered the requirements concerning storage capacity by designing a structure that would hold 1.65 million gallons, of which one million gallons are available within the narrow head range of 25 ft.

Although the tank appears to rest directly on the ground, actually it is supported on a combination concrete and gravel foundation extending slightly above the finished ground surface. The foundation ring consists of a circular reinforced-concrete footing 80 ft. 8 in. in outside diameter and 20 in. thick. The space inside the footing ring has a concrete floor and is packed with gravel. On top of the gravel is a layer of sand 6 in. thick and level with the elevation of the footing. The sand cushion serves as a support for the flattened bottom of the tank as shown in Fig. 2. The circular concrete footing is the support for the 32 vertical rib fins, the load from which is carried to the footing by a skirt plate. The fins are spaced at regular intervals around the tank periphery.

Structural design details

The structural details of the spheroidal tank are shown in Fig. 2. It will be noted that the shape of the tank approximates that which would be assumed by a rubber balloon filled with water and resting on a flat surface. In fact, the theory of the spheroidal design is based upon this knowledge of the shape assumed by

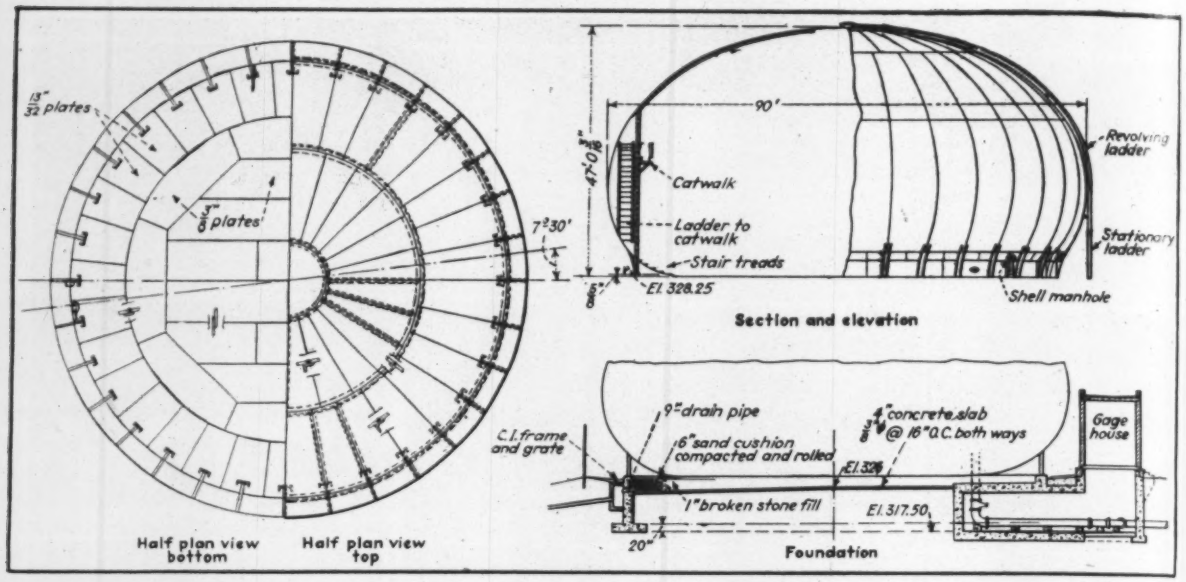


Fig. 2. Design details of the butt-welded tank and the foundation support. Inside the shell plates there are 32 flat rib fins spaced at equal intervals which add rigidity to the structure and transmit vertical loads to the foundation ring. The bottom of the tank is supported on a sand cushion.

an unrestrained container. It follows, therefore, that a steel structure designed to conform to the conditions imposed by nature should be the most economical to build. The economy results from the elimination of practically all the metal used in other structures for the purpose of maintaining form.

Technically speaking, the term "spheroidal" is defined in the specifications prepared by Fay, Spofford & Thorndike, consulting engineers to the Brookline Water Board, as "the form of a symmetrical figure generated by the revolution of a curved shape of varying radii about the vertical axis passing through the center of the curved shape." For a comprehensive discussion of the theory and design of the spheroidal tank the reader is referred to *ENR*, Sept. 12, 1929, p. 416.

From a study of Fig. 2 it will be noted that the shell of the tank consists of curved steel plates, welded into place, all the joints of which are on either vertical or horizontal planes. The thickness of the plates below the first joint above the equator is $\frac{5}{16}$ in.; plates above this joint are $\frac{1}{4}$ in. and the curved plates just above the bottom are $\frac{13}{32}$ in. in thickness. The flat plates on the bottom are $\frac{3}{8}$ in. thick.

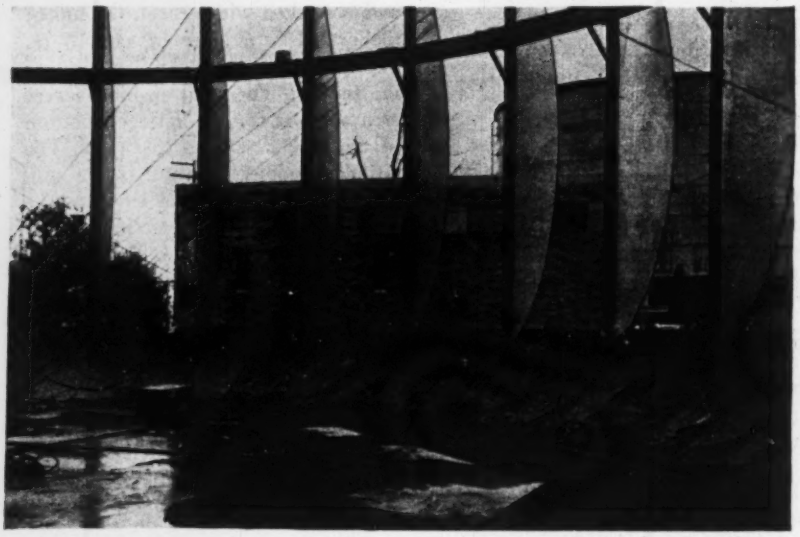


Fig. 3. Flat rib fins in the form of a segment of circle are attached to the skirt plates of the tank. An interior catwalk is installed near the top of the fins.

To add rigidity to the tank and also carry vertical loads, flat rib fins in the form of a segment of a circle are spaced at equal intervals around the inside of the tank. These fins are made of $\frac{1}{4}$-in. steel plate and 10-in. channels. There are 32 of them. They are welded to the steel shell and transmit vertical loads to the skirt plates of the tank and rest on the concrete ring foundation. The shape of the fins and the method of attachment are shown in Fig. 3.

Auxiliaries to the tank consist of two ladders, an interior catwalk, two manholes, and overflow piping. One of the ladders is curved to fit the outside of the tank, and is attached to the finial so that it can be revolved and easily moved to any part of the outside surface; the other ladder is on the inside of the tank and extends from the bottom to the catwalk.

The catwalk provided with a railing is attached on the inside shell about 25 ft. down vertically from the highest point of the tank. A trapdoor about 2 ft. square is placed in the roof so that it can be conveniently operated from the exterior ladder. Just above the bottom of the tank a manhole is located as shown in Fig. 4. The overflow arrangements consist of a splash headpan at the top of

the tank connected to a 16 x 16-in. steel plate box welded to the inside of the shell and leading to an outlet in the bottom of the tank. The water inlet pipe is brought up through the bottom of the tank.

Phosphoric pickling process

Of special interest in the fabrication of the tank was the use of a recently developed phosphoric pickling process to remove mill scale from the plates. For the Brookline structure the plates were dished and the edges prepared for welding before the pickling operation.

As described by M. E. Smith of the Chicago Bridge & Iron Co., the operation consists first of placing the plates into a warm solution of sulphuric acid until all of the mill scale has been removed. Then the plates are washed twice with warm water to remove the sulphuric acid.

Next, the plates are dipped into a warm phosphoric acid bath to which a small amount of iron has been added. This last bath removes any remaining traces of sulphuric acid and leaves a thin coating of iron on the surface of the steel which acts as a rust inhibitor and improves the bond between the metal and the paint which is applied promptly. Leaving the final bath, the plates are placed in racks and a coat of special paint is applied while the plates are still warm. The residual heat in the plates hastens the drying of the paint. By painting the plates immediately after they come from the pickling process there is no chance for film or dirt to collect on the surface.

The use of the phosphoric pickling process enables steel to be painted as soon as it is erected. If the mill scale were not removed by pickling or sandblasting, it would be necessary for the structure to stand for several months until the scale rusts off before the paint could be applied. In addition to allowing prompt painting, says Mr. Smith, the pickling reduces maintenance, as the first coat of special paint forms a good bond with the metal and lasts longer than the ordinary cost of field paint.

Welders hard to find

As was previously stated, the tank is an entirely welded structure. In order to secure welders properly qualified for this work, based on standards of the American Welding Society, some 175 men were tested,

Fig. 4. Base detail showing pedestals, skirt plate and lower manhole.

of which number only 10 passed the complete tests. Because of a Massachusetts law which requires contractors on public work to use men who are residents within the state, the erector was unable to use skilled welders already in his organization. It is said that the qualification tests for welders delayed the job for about five weeks.

The Brookline tank is located on Single Tree Hill, the highest point in the town and one of the best residential areas. The ground owned by the Water Board is at El. 328, and deed restrictions on the property prohibit a structure appearing above El. 375. The top of the tank, therefore, was kept at this elevation.

A successful job at making the structure inconspicuous was accomplished by surrounding the tank with huge evergreen trees (some of these are over 35 ft. in height) and by applying a special gray paint. The color and gloss of the paint, plus the rounded shape of the tank, are such as to make the structure blend with the sky where it shows above the trees.

At the time of this writing tensometer measurements are being made to determine actual stresses at several locations for different stages of water level. The results indicate that the actual stresses in all cases are safely below design stresses.

Who did it

The adaptation and installation of this new type of tank for water service was a cooperative project enlisting the efforts of town officials, the consulting engineers and manufacturers. Walter B. Bushway is superintendent of the Brookline Water Board, and Fay, Spofford & Thorndike of Boston served as consultants; E. B. Myott of that firm had direct supervision of the work.

The Chicago Bridge & Iron Co. prepared the detail designs and also erected the tank; Clyde Cochrane was superintendent of construction. The foundation and a gage house were built by Grande & Volpe, Inc., contractors, Walden, Mass. Olmstead Brothers, of Brookline, did the landscaping. Little & Russell, of Boston, were employed for architectural work.

The total cost of the job was $92,750; of this amount the tank cost $37,850. The foundation of the tank and the gage house cost $20,000, while landscaping and grading totalled $12,800.

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Sanitation for Swimming

Public health as affected by the sanitary conditions of swimming pools is discussed from different points of view in a bulletin, "The New Swimming Hole," issued by the Illinois Department of Public Health (Division of Sanitary Engineering). Attention is called to the matter of maintenance, since pumps, chemical feeders and other apparatus are likely to become inefficient without proper inspection, attention and repair. Unsanitary pools are the cause of many infectious diseases, yet numerous draw-and-fill pools, or those with inadequate filter area, continue to be operated as definite hazards to public health. In 1938, therefore, the department started scoring or classifying the pools in five classes, according to conditions of equipment and operation. Of outdoor pools, only 4.8% had the highest rating and 33.6% had the lowest. Of indoor pools, 4.5 and 10% had the highest and lowest ratings, respectively, while 36% were in the third class.

As to swimmers' complaints that irritation of eyes and skin is due to excess chlorine in the water, the department considers that few pools get enough chlorine to cause these troubles. The cause is more likely to be alum, which, the bulletin says, most operators use to excess. Poor drainage of walks and inadequate slope of overflow gutters are other causes of dirt and other foreign matter polluting the pool.

Test Tube Technique In Sewage Treatment Research

E. J. CLEARY
Assistant Editor, Engineering News-Record

Contents in Brief—From an attic room in a small building on the Rutgers University campus occupied by the New Jersey Sewage Experiment Station have come many of the significant findings which have advanced sewage treatment practice. Now this famous research center, exponent of test tube technique, has moved to spacious new quarters. This is the story of the laboratory and how it operates.

LOADED DOWN with data books, test tubes and a varied assortment of experimental apparatus, the staff of the New Jersey Sewage Experiment Station trudged across the Rutgers University campus a few weeks ago to a new home. And thus begins a new era in the life of a research laboratory whose practical findings have been one of the vitalizing forces in sewage treatment progress during the last decade. There are few phases of sewage treatment to which it has not made significant contributions, nearly all of which have had wide practical application. Most notable and best known, perhaps, of the earlier studies were those on sludge digestion, from which has come much of present-day design and operating practice associated with this process.

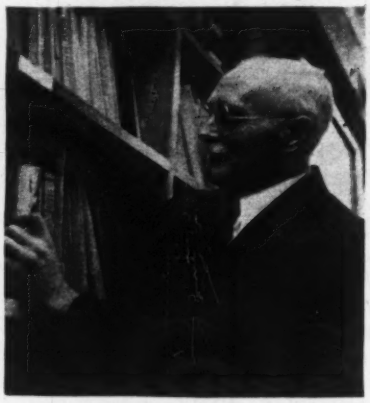


Fig. 1. Willem Rudolfs, chief of research at the New Jersey Sewage Experiment Station.

From crowded quarters on the attic floor of a small building where work was started in 1921, the experiment station has transferred its activities to spacious laboratories housed in a renovated factory building. But the new laboratory, like the old one, is not a place of large tanks, pumps or like bulky equipment generally associated with sewage treatment operations; the apparatus consists largely of simple but ingenious assemblages of glass tubes and bottles. Asked about this, Willem Rudolfs, chief of the station since its inception, said:

"Effective research depends primarily upon the individual and only secondarily upon facilities and equipment. These enlarged quarters merely make it possible to expand the type of work we have been doing. But we are not interested in semi-plant-scale experimentation, which is inflexible and expensive. Our primary interest lies in fundamental studies of basic principles, and these can best be made with closely controlled laboratory facilities. When 'test tube' findings have been made, we then apply them to plant operation where their validity may be confirmed or rejected at a minimum of expense and trouble."

Phases of research

Research directed toward the improvement of sewage treatment, says Dr. Rudolfs, logically falls into three classes of study—biological, chemical, and engineering. The laboratory, therefore, is functionally and physically arranged to serve these three primary divisions of investigation, and each division is in charge of a specialist.

In the biological section of the laboratory are installed facilities necessary for the propagation, identification and measurement of the behavior of bacteria. The principal items of equipment are those which provide precise control of temperature. For this purpose there are two small insulated rooms, and six in-

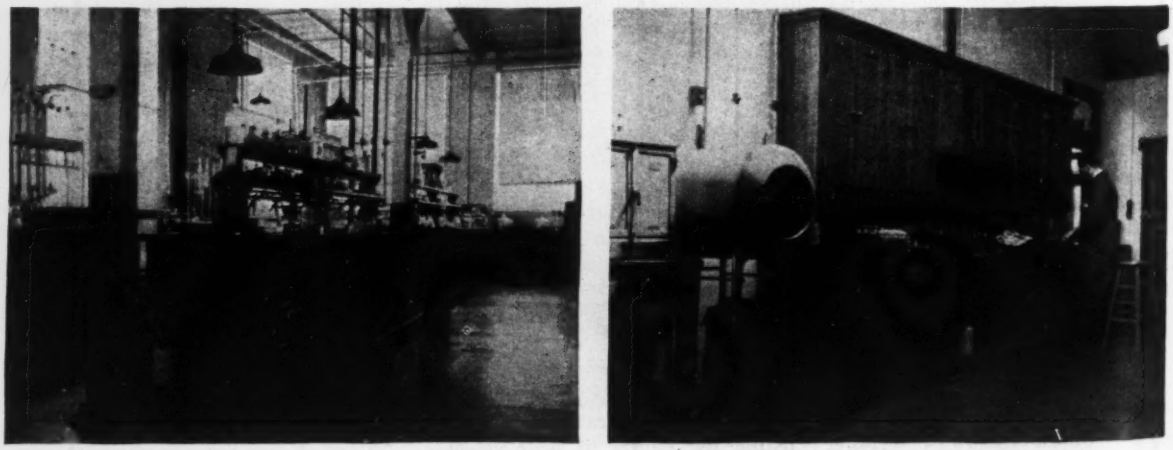


Fig. 2. Chemical and bacteriological laboratories occupy part of the factory building converted into a research station.

cubator cabinets. In the "cold" room a constant temperature of 40 deg. F. is maintained, and in an adjoining room the temperature is kept constant at 70 deg. F. The incubators, each of 6-cu.ft. capacity, can be operated at constant temperatures varying anywhere between 40 and 150 deg. F.

Biological investigations are conducted along two fronts: (1) to obtain basic data on the behavior of pure cultures of a single type of organism; and (2) to evaluate the gross behavior of groups of organisms as measured by their intermediate and end products. For example, in recent studies directed toward improvement of activated-sludge treatment, the first job undertaken was to isolate the organisms that perform in the process. Some 18 different species were thus identified. The next step was to study the role of each organism and then determine the net effect of groups of organisms. Only through an intimate and basic study of this kind is it possible to piece together clues which may eventually throw light on the mechanism of the process.

But an understanding of biological activities is only part of the story. Biochemical relationships must be studied simultaneously with bacteriological activity, because bacteria not only initiate chemical changes but in turn may not function without completion of some of these changes. And to complicate matters still further, the influence of physical phenomena such as, for example, surface tension of liquids, must be integrated with the biochemical and bacteriological studies. This illustrates the type and scope of research in the biological laboratory.

Chemical laboratory

Occupying an equally important place in the workshop is the chemical laboratory. While it is not elaborately equipped, it contains many pieces of apparatus adapted for special conditions. The newest acquisition is a photo-electric cell apparatus for measuring the turbidity of sewage effluents. With this device it is possible to take a very small sample (3.5 c.c.) and accurately determine the turbidity, even in the low range of 0–20 ppm. The development of this technique, incidentally, is one of the recent practical contributions of the experiment station. (See *Sewage Works Journal*, January, 1939, p. 3).

Another interesting piece of apparatus is that for making microanalyses. By this means, using only a droplet of liquid, there can be made a complete chemical analysis including the determination of constituents and reaction changes. This technique has been adapted from and is similar to that now widely used in industrial plant control.

The principal studies made in the chemical laboratory concern the effect of chemicals on sewage and subsequent treatment processes. These chemicals may be present in the form of industrial waste, or may purposely be added to aid in the clarification of sewage.

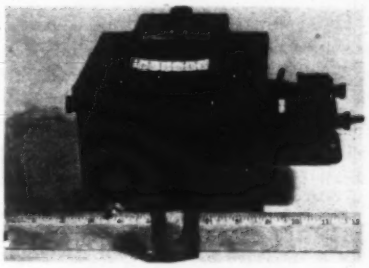


Fig. 3. The newest tool for sewage research which was recently developed at the station is a photoelectric cell device for measuring turbidity of liquids.

The engineering section of the experiment station deals specifically with plant control and design, and provides a means whereby actual field tests of laboratory findings can be made. Much of this work is done in cooperation with state institutions where plants have already been built or are to be constructed; in fact, the experiment station is charged with the responsibility of supervising the operation of sewage treatment at state hospitals and other institutions.

Variety of activities

This brief summary merely highlights the principal activities of the New Jersey Sewage Experiment Station. Many related studies in sanitation and water supply are also given attention. One of the more interesting investigations dealt with mosquito control, in which it was established that the reason why mosquitoes seek out humans is because of the mosquito's attraction to carbon dioxide. Incidentally, this fact formed the basis for the development of a mosquito repellent that was put on the market recently.

Dr. Rudolfs relates that he stumbled upon the carbon dioxide relationship by accident one day when he breathed into a test tube containing mosquitoes. This caused so much activity on the part of the mosquitoes that he immediately made further investigations which led to the discovery that a similar and even more violent reaction occurred when mosquitoes were subjected to an atmosphere of pure carbon dioxide gas. Later tests confirmed the fact that mosquitoes would be attracted to any source of carbon dioxide concentration, be it a center of population, a polluted stream with its decomposing sludge, or a human being.

The newest study of unusual character is one concerning the presence and utilization of growth-promoting substances in sewage. Some 15 organic growth producers of the hormone type have already been isolated and are now being qualitatively and quantitatively examined. Minute quantities of these substances—measured in parts per billion—have been found to have remarkable stimulating effects on plant growth. They are present in sewage sludge, and are believed to be the reason why sludge has such potency as a soil fertilizer.

Research and the future

Prompted to make a statement concerning future progress in sewage treatment, Dr. Rudolfs forecast that sludge digestion practice may be revolutionized. He believes, from recent findings in the laboratory, that digestion can be accelerated by use of a two-stage process in which environmental conditions in each stage will be maintained so as to stimulate the activity of certain bacteria and retard undesirable forms. The net result will be faster digestion, more gas production and easier operating control.

The sewage experiment station, which is a division of the New Jersey State Agricultural Experiment Station affiliated with Rutgers University at New Brunswick, N. J., includes the following staff members: Willem Rudolfs, chief; H. Heukelikian, associate in charge of biological investigation; G. M. Ridenour, associate in charge of engineering; and Harry Gehm, associate in charge of chemical investigation.

The following are research assistants on the staff: Clarence Henderson, Robert S. Ingols, W. A. Moggio, B. Heinemann, and M. L. Littman.

Garbage Digested With Sludge At Small Treatment Plant

First installation of its kind in New York State, this combination disposal works will serve a village of 3,200 people

GARBAGE and sewage disposal are combined in a new plant serving 3,200 people at Goshen, N. Y. The garbage is brought to the plant where it is macerated in a hammermill grinder, mixed with sewage sludge, and then digested in heated tanks. The digestion tanks are identical in design and construction with those normally used for sludge digestion, except that they provide additional capacity for the garbage solids.

The garbage-grinding facilities were incorporated in the Goshen plant as part of a remodeling program. The original plant, built in 1914, and consisting of septic tanks and sand filters, was converted to provide sedimentation and sand filtration, with separate sludge digestion. The new settling tank (600,000 gpd capacity with two hours' detention) is equipped with straight-line sludge scraping equipment. Settled sludge will be discharged by gravity to a pneumatically-operated ejector tank. The ejector tank has been installed directly under the grinder to receive the macerated garbage.

The grinder is housed in a brick structure directly below a charging hopper. This hopper is placed in the center of a concrete floor on which the garbage trucks dump their content. The general plan of operation is to fill the ejector partly with raw sludge, and then grind sufficient garbage to fill the tank. The complete charge is then blown off into the primary digestion tank and the cycle is repeated. By this means a preliminary mixing of sewage solids and garbage will be accomplished to insure more rapid digestion.

Gas explosion prevention

The primary and secondary digestion tanks are interconnected with pipes to facilitate transfer of supernatant liquor. Transfer of sludge, however, will be accomplished by first passing it through the ejector tank. Since the digestion tanks are constructed with fixed concrete covers, provisions have been made to automatically replace the volume of sludge and supernatant withdrawals with raw sewage, and thus minimize explosion hazards. The latter might result from the admixture of air with sludge gas contained in the tank. To add raw sewage a small 300 gpm centrifugal pump, equipped with a float-operated switch, is used.

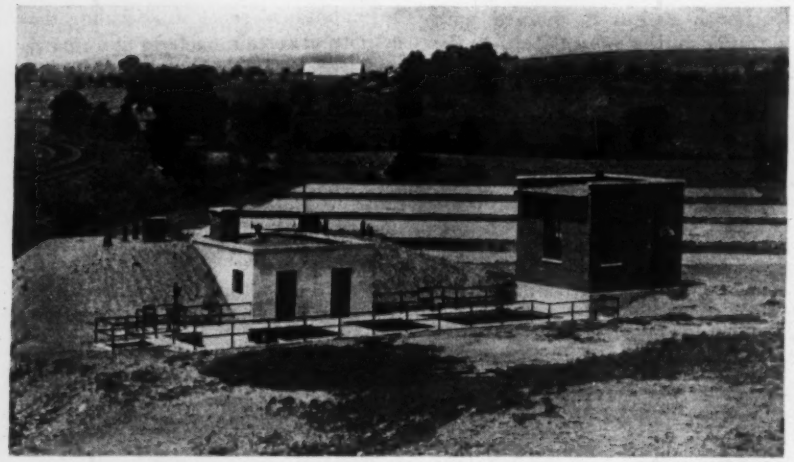


Fig. 1. Garbage disposal is combined with sewage treatment at this compact plant. Garbage is ground in the brick building and then ejected to the tanks at the left where it is digested with sludge. The sand sewage filter beds are in the background.

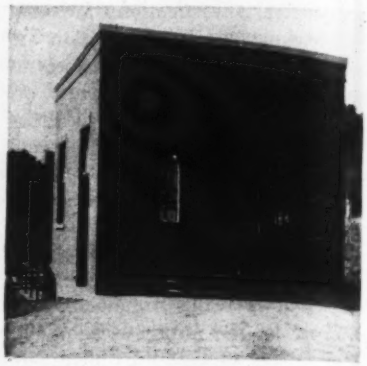


Fig. 2. Charging floor in the garbage grinding building.

Digestion tank capacity is 4.0 cu. ft. per capita. This is about twice that normally provided for sedimentation plants, the extra capacity representing the allowance for the addition of garbage solids. At Lansing, Mich., where garbage is ground and ejected directly to sludge digestion tanks, the capacity of the digestion tanks is reported to be less than 3.0 cu. ft. per capita; the Lansing plant is much larger than that at Goshen, however, and is designed to handle the load from 100,000 population.

It is estimated that weekly wet sludge additions will be about 38,000 lb., and that the wet ground garbage will total 12,000 lb. On a volatile solid basis, a ratio of 1 to 0.75 ground garbage to sewage sludge is expected. The garbage is ground to a size that will pass a ¼-in. screen opening.

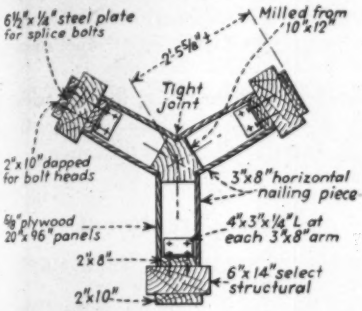
Henry W. Taylor, consulting engineer of New York City, designed and supervised construction of the Goshen plant. Claude A. Bonaparte was resident engineer, and Donohue-Murphy, Inc., of White Plains, N. Y., were the contractors. The special raw garbage grinder was furnished by the Jeffrey Manufacturing Co. of Columbus, Ohio. Walter G. Brown is the mayor of Goshen and J. B. Connelly is village clerk. John Bradley is plant operator.

FROM FIELD AND OFFICE

Working problems and time-saving methods . . . Edited by Charles S. Hill

Tall Columns with Plywood Webs

Twenty-four tall timber columns are used for architectural effect in the main entrance to the California group of buildings at the San Francisco World's Fair. Objectives were the long graceful lines of a colonnade by day and concave surfaces suitable for reflecting floodlights by night. A



Section of Y-shaped plywood web columns used at Golden Gate Exposition.

Y-section was chosen which gives each column three reflecting faces. As the height is 85½ ft. care was needed in providing for wind loads and earthquake stresses. Plywood made it possible to meet these requirements with columns of relatively light weight.

In plan the colonnade is laid out in two circles, 94 and 68 ft. in diameter, respectively, with 12 columns in each. The foundation for each column is a wooden pile with a cantilevered timber cap on which the columns stands. Very little live load is carried and a roof tying the columns together near the top and framing into the adjoining buildings, made it possible to consider the columns as fixed at both ends. Because of this fixity, the $\frac{L}{r}$ ratio of 63 was not considered excessive.

The section selected, as shown in the drawing, is essentially a vertical girder made of timber and having three flanges, instead of the customary two, and three pairs of webs. Five-ply, ⅝-in. Douglas Fir plywood, firmly nailed with 6-d. galvanized nails, is used for the webs, which meet on a common nailing block in the center. With the timber sizes shown, this shape figures for a wind load of 15 lb. per sq. ft. and a horizontal force of 0.1 *g*. An important part of the plywood function is to resist the torque from wind that produces an unbalanced load around the vertical axis. The roof or deck is a light timber framing on which 1x8-in. diagonal sheathing carries horizontal loads into the adjoining buildings.

The columns were designed by the California Commission for the Golden Gate International Exposition under the direction of C. E. Seage, assistant executive officer in charge of plans and estimates.

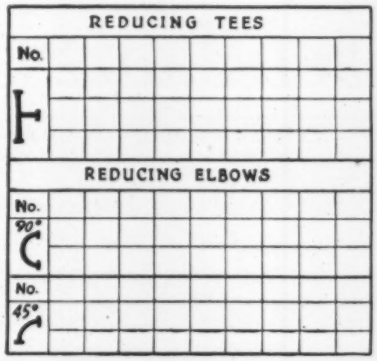
CAMERA MEMORANDA

Safety suggestions from workmen are invited, at Grand Coulee Dam, by a pad of paper and a suggestion box fastened in a convenient place on the job. A pad of note paper is nailed to a board painted white to make it conspicuous on the timber falsework, and a pencil is conveniently hung nearby. The contents of the box are picked up regularly by a member of the safety crew.

A Simple Stock Record

W. F. SCHAPHORST
Newark, N. J.

Here is an ingenious and simple method for keeping a record of pipe fittings developed by an engineer with a large eastern engineering and contracting company. For example, where reducing tees have three different sizes of openings, as often happens, the problem of recording those openings in an orderly manner has heretofore always been a sticker. The accompanying reproduction of a blank used by this engineering concern shows how easily it can be done. Similarly, reducing elbows and return bends can be checked or recorded on the same blank. The blank therefore tells the whole story without the necessity of vexing explanatory remarks such as are to be found attached to the usual records of fittings of this character.



Blank for recording pipe fitting stock.

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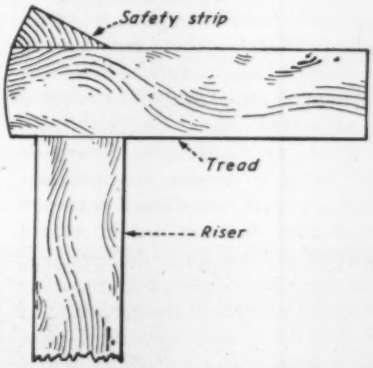
Safety Strips on Steps

A wood "safety strip" has been devised by Consolidated Builders, Inc., contractors on Grand Coulee Dam, to make steep stairways safer for workmen, particularly when descending the steps. The strips are made from 1 x 2-in. pine lumber, ripsawed diagonally and nailed to the tread as shown in the accompanying sketch. These strips are believed to lessen the danger of slipping where the slope is steep. They are used on stairways with slopes as steep as 0.8 to 1.



A wooden strip is nailed on the outer edge of each tread to lessen danger of slipping.

BOOK NOTES AND REVIEWS

The month's additions to the engineer's reading and reference list

State Building Code For California

BUILDING CODE FOR CALIFORNIA—Edwin Bergstrom, editor. 472 pp. Published by the California State Chamber of Commerce, San Francisco, Calif. Price $5.

The California building code was prepared for the California State Chamber of Commerce by committees representing state and national organizations of architects, engineers and contractors. It was edited by Edwin Bergstrom, architect, with Henry D. Dewell, civil engineer, as co-editor during the early years of the work. The structural design sections were written fundamentally under Mr. Dewell's editorship.

Need for a statewide building code that would safeguard buildings against earth movements was made evident by the increases in insurance rates that followed the earthquake of 1925 which centered in Santa Barbara and the recession in building that resulted from the increase. The Long Beach earthquake stimulated interest in such a code and resulted in the passage of the Field bill requiring plans for all school buildings in the state to be approved by the division of architecture of the Department of Public Works. In 1933 the division adopted almost in their entirety the provisions of the present code relating to structural design and earthquake resistance then complete.

Most notable in the code are parts 34 to 40, comprising the provisions governing structural safety and design and protection against earthquakes. They constitute that part of the code which is substantially the same as the state regulations adopted to safeguard school building construction in California. Allowable unit working stresses for masonry, plain concrete, reinforced concrete and timber framing are in accord with stresses used in current practice. Unit working stresses permitted for structural steel, with the exception of bearing on rivets, bolts and pins, which stresses are materially lower, agree with those recommended in the 1939 edition of "Steel Construction," published by the American Institute of Steel Construction. These stresses may be considered high by some designers. All structural steel is required to conform to the Standard Specifications for Steel for Bridges, A7-36, of the American Society for Testing Materials. Electric-arc welding with electrodes suitably coated so as to properly shield the arc is permitted for the connection of structural steel parts and members.

The code is presented in a form for ready adoption by municipalities and requires only minor modifications to make it conform to existing local laws. It is essentially sound and is superior to other codes in that a logical sequence is maintained throughout its length, and complete information relative to the classification of buildings as to occupancy, construction and other limiting requirements is presented by means of tables. It represents the best efforts and thoughts of a number of competent and impartial men—*Reviewed by* E. M. KNAPIK, *civil engineer, San Francisco, Calif.*

Railway Engineers

HISTORY OF THE SIXTEENTH ENGINEERS (RAILWAY)—365 pp. Compiled and published by the 16th Engineers Veterans Association, 805 Military Ave., Detroit, Mich. Price $2.50 to members of the regiment; $5.00 to others.

Twenty years after the close of the World War the record of another of the engineer regiments that participated in that conflict has been assembled in permanent form. Early in the summer of 1917 thousands of young engineers signed up for service in nine regiments (the 11th to the 19th Engineers) for railroad construction and operation in France. Within a few weeks they were sent abroad, three regiments behind the British front and the remainder behind the French front building and operating both standard-gage and light railways, building storage yards, ammunition depots and the like. The 16th was one of the construction regiment. It built the great base at Is-sur-Tille, the Nevers Cutoff and the Marcy Engine Terminal, and later participated in the Meuse-Argonne offensive. The regiment also served on the British front in the spring of 1918 building railway lines.

Sewage Disposal

OHIO CONFERENCE ON SEWAGE TREATMENT—160 pp. Published by Ohio Conference on Sewage Treatment, Room 302, Department of State Building, Columbus, Ohio. Price, $1.25.

Papers dealing with a variety of current developments in disposal practice are published in a report of the Ohio Conference on Sewage Treatment. Of major interest are those dealing with activated-sludge bulking, aero-chlorination for grease removal, sludge digestion studies at Cleveland, and gas engine operation at Toledo. Also included is a research committee report dealing with the history, development and pertinent features of sewage filtration.

Water Treatment

WATER SUPPLY AND TREATMENT, by Charles T. Hoover, Water Softening and Purification Works, Columbus, Ohio. 146 pp. Published by National Lime Association, Washington, D. C. Price 50c.

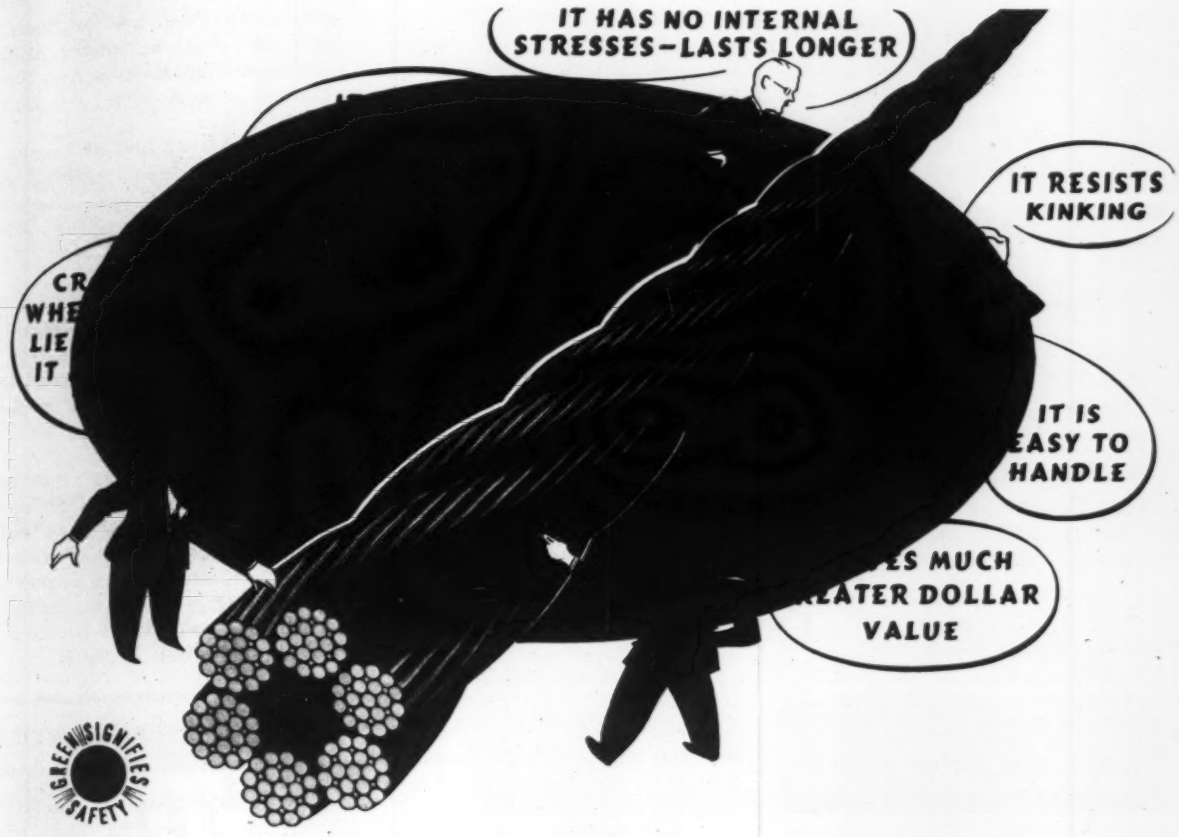
One of the best practical books on water supply and treatment has now been made available in a third edition. It is a cogent and well illustrated text dealing primarily with treatment processes and their applications. Particularly valuable is a chapter on methods of water analysis which sets forth, in an easily understandable manner, the procedure in making tests and the preparation of reagents for laboratory experiments. For the plant operator and engineer the text will serve as a handy reference handbook; for public officials and civic groups it furnishes a brief, well rounded discussion of principles.

Jobs for Engineers

ENGINEERING OPPORTUNITIES—By a group of authors with R. W. Clyne as editor. 397 pp. Published by D. Appleton-Century Co., New York and London. Price $3.

Vocational guidance in engineering has been aided by this book which brings together within reasonable limits twenty-six statements as to the opportunities for engineers in that number of industries. Unfortunately for the civil engineer, his field gets

(*Continued on p.* 80)



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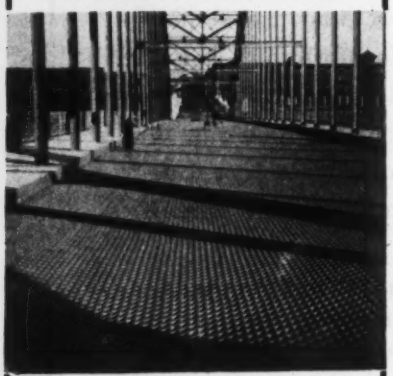
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(Continued from p. 78)

scant attention. The only sections which relate to it are "architecture and city planning" and "building construction." Nothing is said on such fields as highway construction, bridge building, sanitary engineering, general construction, irrigation, power development or the vast field of municipal engineering. Observations made by some of the authors as to qualifications required for their special field will be found particularly helpful to young men getting started. All should read Karl T. Kompton's foreword.

MISCELLANEOUS NOTES ON BOOKLETS AND REPRINTS

ZEOLITIC COPPER COMPOUNDS as fungicides are described in a dissertation prepared by A. A. Nikitin of the Tennessee Copper Co., Research Division, Copper Hill, Tenn.

PUBLIC HEALTH AND SANITARY ENGINEERING training opportunities offered by the University of North Carolina are outlined in Bulletin No. 343. Address D. G. Baity, Professor of Sanitary Engineering, Chapel Hill, N. C.

HOUSING COSTS are summarized in tabular and graphic form in Housing Monograph Series No. 3, Land Materials and Labor Costs, prepared for the Industrial Committee of the National Resources Committee. Copies may be obtained from the Superintendent of Documents, Washington, D. C. Price 30c.

A PRIMER OF CITY PLANNING under the title of "From the Ground Up" has been prepared by the New England Regional Planning Commission of the National Resources Committee, 2100 Federal Bldg., Boston, Mass. The purpose is to make regional planning clear to selectmen, city counsellors and the man of the street.

HIGHWAY SAFETY is the subject of two pamphlets recently published, one entitled "A Review of the Literature Relating to the Various Psychological Aspects of Highway Safety" is Research Series No. 66, Engineering Experiment Station, Purdue University, Lafayette, Ind. (price, 25 c.). The other is "Standard Highway Safety Programs for States," published by the Automotive Safety Foundation, 366 Madison Ave., New York (no price given).

AN UP-TO-DATE LIST of American standards has been published in pamphlet form by the American Standards Association, 29 W. 39th St., New York City.

SPECIFICATIONS for three types of cold-laid asphaltic plant-mix are given in "Construction Specifications," CL-1, CL-2, and CL-3 published by the Asphalt Institute, 801 Second Ave., New York City.

A SUSPENSION BRIDGE STUDY entitled "On the Problem of Stiffened Suspension-Bridges and Its Treatment by Relaxation Methods," a paper for the Institution of Civil Engineers, has been published in pamphlet form by the Institution, Great George St., Westminster S.W.1, England.

NEW ENGINEERING BOOKS

RESULTS OF MUNICIPAL LIGHTING PLANTS—350 pp. Published by Burns & McDonnell Engineering Co., Kansas City, Mo. Price $5.

SCIENCE AND SOCIAL CHANGE—575 pp. Compiled by Jesse E. Thornton and published by The Brookings Institution, Washington, D. C. Price $3.

HEATING AND AIR CONDITIONING—Fifth Edition—By John R. Allen and James H. Walker. 593 pp. Published by McGraw-Hill Book Co., New York and London. Price $4.50.

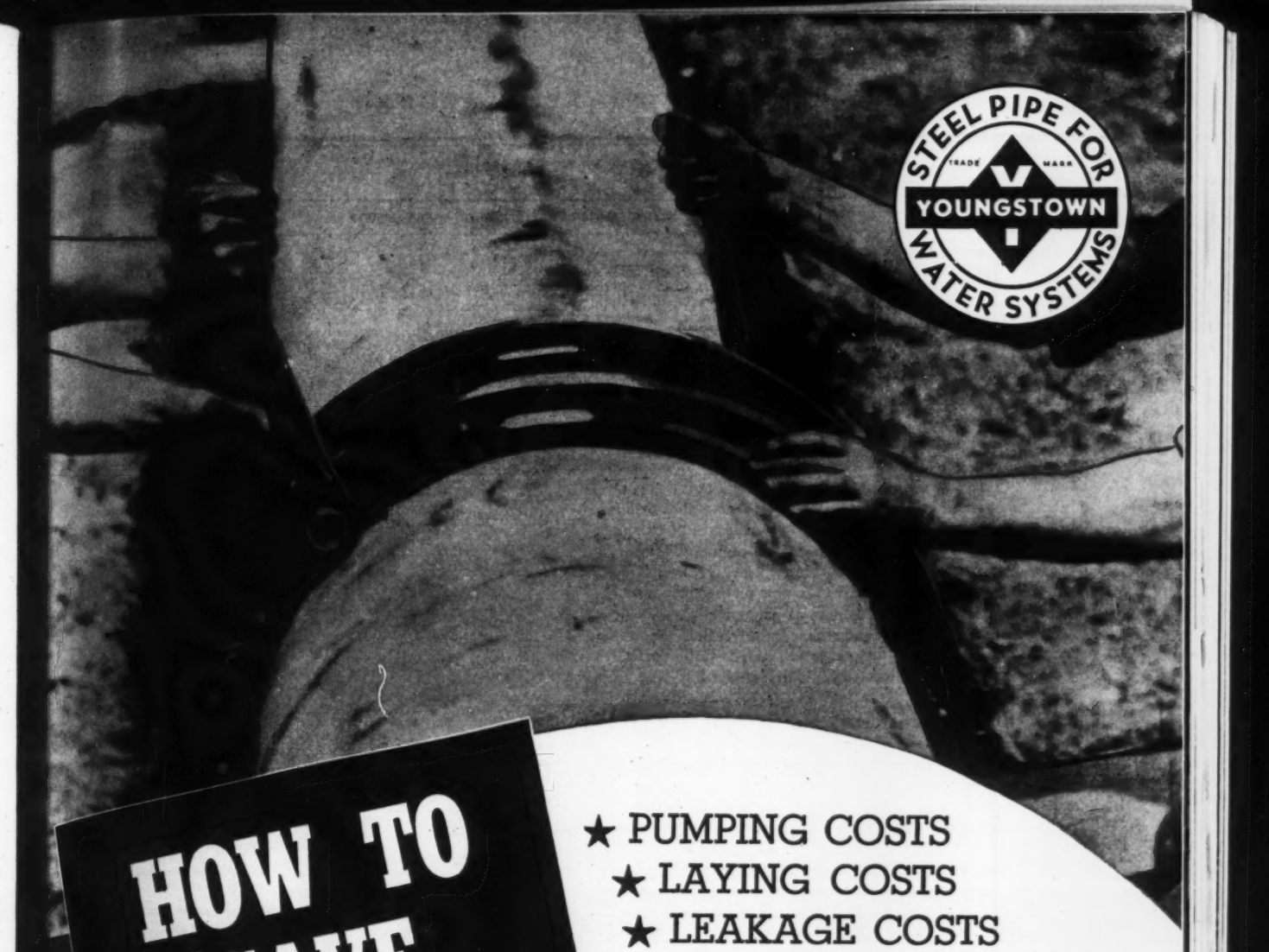
THE LIFE AND WORK OF WILLIAM CAWTHORNE UNWIN—By E. G. Walker. 239 pp. Published by the Unwin Memorial Committee, 15A, Grosvenor Mansions, 82, Victoria St., S.W. 1, London. Price 12s. 6d. Obtainable through the American Society of Mechanical Engineers, 33 W. 39th St., New York, N. Y.

GEOLOGY AND ENGINEERING—By Robert F. Legget. 650 pp. Published by the McGraw-Hill Book Co., New York and London. Price $4.50.

MY FIFTY YEARS IN ENGINEERING—By Embury A. Hitchcock in collaboration with Merrill Weed. 277 pp. Published by the Caxton Printers, Ltd., Caldwell, Idaho. Price $3.

LE CALCUL DES CONSTRUCTIONS SOUDEES—By Lucien J. Vandeperre and Artemy Joukoff. 274 pp. Published by Albert de Boeck, 265, Rue Royale, Brussels. Price, 20 francs.

WOOD STRUCTURAL DESIGN DATA, Volume 1—Second Edition. 296 pp. Published by National Lumber Manufacturers Association, Washington, D. C. Price $1.



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1-6A

CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

LACKAWACK DAM, NEW YORK

OWNER: City of New York, N. Y., Board of Water Supply, Walter E. Spear, Chief Engineer.

PROJECT: Construction of Lackawack Dam (Contract 340), effluent chamber of Rondout Reservoir together with inlet channel and superstructure, blow-off tunnel, waste weir and waste channel of reservoir, north portion of Rondout-West Branch tunnel including Shaft 1, one-half mile of bituminous macadam highway across dam, waste channel bridge, and appurtenances of all these structures. Closure of existing diversion tunnel and final grading also included. Dam is located in Wawarsing, Ulster County, N. Y. Reinforced concrete effluent chamber and waste weir on westerly side of reservoir near dam. Tunnel begins at effluent chamber, runs southeasterly to Shaft 1, and thence to southern limit of contract. Dam to be of rolled earth fill. Slopes to be partially covered by rip-rap; downstream slope also to be covered with topsoil.

CONDITIONS: Ellenville station of N. Y., O. & W. R.R. about 8¾ miles from site of work; Napanoch station about 6¾ miles. Contractor to furnish all materials, except testing equipment and metal work furnished by owner. Suitable earth embankment materials nearby. Rock investigations in vicinity indicate stone to be satisfactory for facing structures, rubble masonry and paving. Time for completion, 72 consecutive calendar months. Skilled wages for general construction on project range from $2.25 per hr. for hoisting engineers to $1.00 for painters; semi-skilled from $1.65 for roller operators to 62½c. for mason's helpers; unskilled, 75c. per hr. Unskilled labor rate in shafts and tunnels, 87½c. per hr.

BIDS: Five bids were opened July 25, 1939, ranging from the contract low of $15,486,150 to $22,134,000. Contract awarded August 16, 1939.

LOW BIDDERS:

1. Mason & Hanger Co., Inc., New York, N. Y. (contract) $15,486,150
2. Jahn-Bressi-Bevanda Constructors, Inc., Los Angeles, Calif. 16,195,700
3. Keystone Company, San Francisco, Calif. .. 16,720,150

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Stream control	L. S.	$20,000.00	$25,000.00	$45,000.00
2. Remove buildings	40,000 s. f.	.20	.15	.20
3. Remove soil	160,000 c. y.	.50	.42	1.00
4. Earth excav., open cut	1,220,000 c. y.	.35	.57	.50
5. Earth excav., sheet. cut-off trench	12,000 c. y.	2.50	8.50	2.30
6. Earth excav., caissons (bottom cut-off tr. to El. 580)	24,000 c. y.	20.00	34.00	23.00
7. Earth excav., caissons (below El. 580)	16,500 c. y.	30.00	34.00	35.00
8. Rock excav., open cut	410,000 c. y.	2.20	1.75	1.80
9. Rock excav., caissons	3,500 c. y.	40.00	50.00	35.00
10. Prepare rock surface	5,500 s. y.	8.00	5.00	5.60
11. Rolled embankment	5,600,000 c. y.	.48	.45	.53
12. Refill and embank	1,250,000 c. y.	.10	.25	.18
13. Rock embankment	1,000,000 c. y.	.45	1.25	.35
14. Surf. dress. and grass	170,000 c. y.	.60	1.50	1.45
15. Conc. masonry, open cut	145,000 c. y.	14.00	11.00	11.50
16. Conc. mason., under air	10,000 c. y.	16.00	25.00	30.00
17. Dry rubble mason., paving	60,000 c. y.	3.50	10.00	10.00
18. Rubble pav. in mortar	11,000 c. y.	5.40	13.00	14.00
19. Rubble mason. and facing in mortar	27,000 c. y.	13.00	16.00	16.50
20. Sandstone, bluestone fac., trim and coping	3,500 c. y.	100.00	70.00	114.00
21. Brick masonry	550 c. y.	36.00	40.00	35.00
22. Conc. roof tiles	1,450 s. y.	14.00	12.00	14.00
23. Granolithic finish	850 s. y.	1.00	1.00	1.20
24. Painting	250,000 s. f.	.03	.05	.045
25. Structural steel	1,850,000 lb.	.07	.08	.07
26. Steel interlining, subst. effluent chamb	1,130,000 lb.	.09	.06	.10
27. Steel sheet piling	2,200,000 lb.	.045	.06	.06
28. Steel, reinf. conc	6,000,000 lb.	.055	.055	.065
29. Aluminum articles	48,000 lb.	1.00	1.20	1.50
30. Timber, lumber, open cut	300 M bm.	135.00	100.00	130.00
31. Bitum. mac. pavemt	3,300 c. y.	6.00	6.00	5.00
32. Bitum. mat'l	55,000 gal.	.09	.10	.08
33. Conc. pavement	1,000 c. y.	6.50	14.00	8.00
34. Sink shaft in rock	13,000 c. y.	25.00	18.00	23.00
35. Excav. tunnels	100,000 c. y.	14.50	11.00	13.00
36. Enlarg. shafts, tunnels	1,500 c. y.	10.00	11.00	17.50
37. Prot. coat. of cem. mortar	2,000 c. y.	25.00	25.00	21.00
38. Str. steel, support, shaft and tunnels	1,500,000 lb.	.07	.07	.09
39. Timbering, sh. and tun	275 M bm.	120.00	100.00	235.00
40. Dry packing	1,200 c. y.	5.00	5.00	6.00
41. Drain. channel, sh. and tun	11,200 l. f.	20.00	7.00	9.00
42. Forms, mason. lin. of shaft	1,000 l. f.	20.00	28.00	47.00
43. Forms, mason. lin., stilling chamb. and incl. spillway and diver. tun	400 l. f. of tun.	100.00	70.00	105.00
44. Forms, mas. lin. of 15 ft. and conn. tun	2,500 l. f. of tun.	25.00	14.00	21.00
45. Forms, mason. lin. of 13.5 ft. tun	6,050 l. f. of tun.	15.00	10.00	9.50
46. Forms, mas. lin. blow-off tun	1,450 l. f.	10.00	10.00	6.00
47. Conc. masonry, shaft	4,600 c. y.	15.00	7.00	16.50
48. Conc. masonry, tunnels	48,000 c. y.	8.00	7.00	9.35
49. Excess conc. masonry	7,000 c. y.	5.00	5.00	5.00
50. Test borings	30,000 l. f.	5.00	5.00	5.00
51. Pumping	350,000 Mil. f. g.	.25	.25	.25
52. Drill holes, rock, mason	50,000 l. f.	1.00	1.00	1.00
53. Steel pipes, grouting	30,000 l. f.	.80	1.00	.60
54. Conn. for grouting	4,000 ea.	3.00	4.00	4.00
55. Mix and pl. grout	25,000 c. y.	14.00	8.00	15.00
56. Portland cement	570,000 bbl.	2.20	2.15	2.30
57. Bitum. cur. solut., conc. masonry	100,000 s. y.	.08	.10	.14
58. Cr. stone and grav	5,200 c. y.	3.00	3.00	4.00
59. Sand for filters, grout and prot. coat cem. mort	6,000 c. y.	4.00	3.00	4.00
60. Granite curb	1,300 l. f.	4.00	5.00	5.00
61. Steel pipe, fittings	285,000 lb.	.10	.10	.14
62. Grating, ladders, stairs	135,000 lb.	.20	.20	.17
63. Cast iron pipe and fittings	83,000 lb.	.10	.15	.11
64. Misc. c. i., wrt. iron, steel	2,200,000 lb.	.12	.10	.13
65. Galvanizing	650,000 lb.	.03	.03	.05
66. Misc. bronze, brass, copper, lead	75,000 lb.	.80	.60	.70
67. Inst. and test equip. and metal-work furn. by owner	2,000,000 lb.	.04	.05	.04
68. Vit. pipe and conduit	10,000 l. f.	1.50	1.00	1.20
69. Chlorinators	2 ea.	5,000.00	5,000.00	4,000.00
70. Liquid chlorine	50,000 lb.	.10	.10	.08
71. Sanitary services	L. S.	75,000.00	35,000.00	150,000.00
72. Cleaning up	L. S.	10,000.00	35,000.00	25,000.00

LEVEES, KENTUCKY

OWNER: U. S. Engineer Office, Louisville, Ky.

PROJECT: Construction of earth levees, drainage structures, toe drains, and movable closure structures in northwestern part of Paducah, Ky., on left bank of Ohio River. Protection works start near intersection of Sixth and Burnett Streets, extend in westerly direction to point on Illinois Central R.R., east of Perkins Creek, thence in southerly direction to point on 32nd Street, west of Boswell Road.

CONDITIONS: Contractor to furnish all materials, and complete project in 500 calendar days excluding time lost for flooding or rains. Borrow areas for embankment construction will be furnished without cost to contractor. Wage rates: skilled, $1.00 to $1.25 per hr.; semi-skilled, 50 to 75c. per hr.; and common, 40c. per hr. Rail, water and highway transportation available.

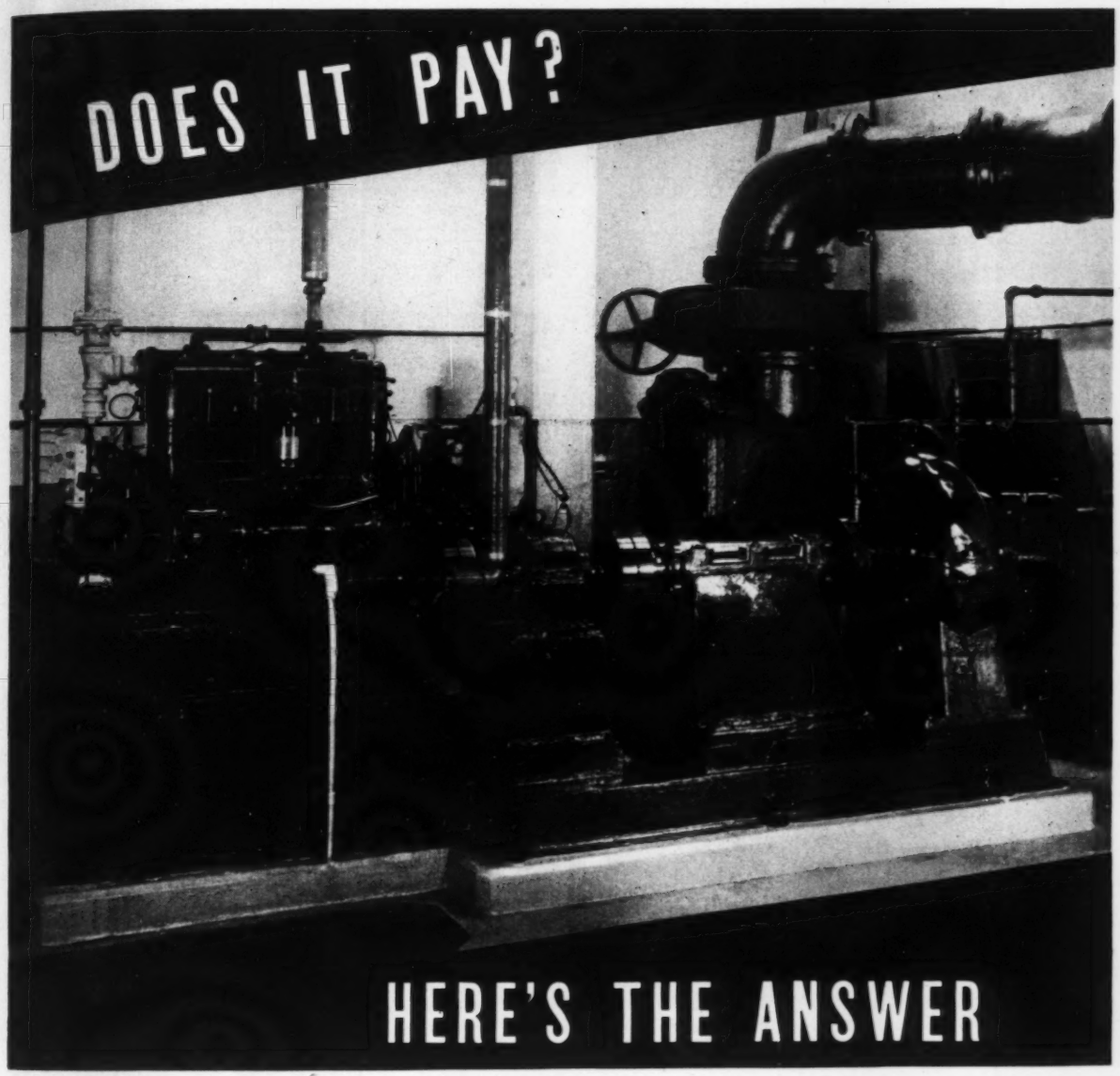
BIDS: Seven bids were opened July 7, 1939, ranging from contract low of $140,237 to $181,457.

LOW BIDDERS:

1. L. O. Brayton & Co., Dyersburg, Tenn. (contract) $140,237
2. Hart & Hart, Columbus, Ind. 148,878
3. Hodgkin-Adams Co., Inc., Winchester, Ky. 152,874

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Levee embankment	388,400 c. y.	$0.205	$0.23	$0.22
2. Rolling (3 add'l passes)	30,000 sq.	.01	.0025	.02
3. Concrete	475 c. y.	25.00	20.50	25.00
4. Reinforcing steel	29,200 lb.	.05	.045	.05
5. Miscellaneous metal	2,120 lb.	.20	.022	.15
6. 12-in. corr. iron pipe	67 l. f.	2.00	1.72	2.00
7. 24-in. corr. iron pipe	459 l. f.	3.50	3.60	3.50
8. 30-in. corr. iron pipe	134 l. f.	5.50	5.88	6.50
9. 60-in. corr. iron pipe	318 l. f.	15.00	17.35	18.00
10. 72-in. corr. iron pipe	197 l. f.	20.00	21.30	22.00

(Contract Unit Prices continued on page 84)



The above illustration shows the engine referred to in the accompanying report. This engine operates on sewage gas in the treatment plant of a mid-western city of 45,000.

DATA FROM THE MANAGING ENGINEER'S REPORT

Le Roi Engine No. 117920 started	September 13, 1936
Total operating time	23,655 hours
Percentage of total elapsed time during which engine has operated	97.1%
Total amount of sewage pumped	4,285,000,000 gals.
Average daily consumption of gas	10,140 cu. ft.
Total cost of operation including lubrication, repairs, labor, etc., per million gallons	14.9 cents
Total cost of operation when operating on purchased power before engine was installed, per million gallons	61.0 cents

LE ROI COMPANY MILWAUKEE, WIS.

(Contract Unit Prices continued from page 82)

11. Seep ring, corr. iron, No. 10 Ga.	2,180 s. f.	1.50	1.25	1.50
12. Flood gate, 24-in.	3 ea.	90.00	58.00	100.00
13. Flood gate, 30-in.	1 ea.	150.00	103.00	150.00
14. Flood gate, 60-in.	2 ea.	600.00	550.00	600.00
15. Flood gate, 72-in.	1 ea.	725.00	600.00	800.00
16. Riprap, hand placed	130 c. y.	6.00	7.45	7.00
17. Gravel blanket	80 c. y.	3.00	2.10	3.00
18. Common excavation	1,100 c. y.	.75	.45	.50
19. Backfill, compacted	1,120 yd.	1.50	.75	1.30
20. 8-in. toe drain, 4-6-ft.	4,455 l. f.	1.00	1.15	1.50
21. 8-in. toe drain, 6-8-ft.	150 l. f.	1.40	1.15	2.25
22. 12-in. toe drain, 4-6-ft.	3,610 l. f.	1.50	2.14	2.00
23. 12-in. toe drain, 6-8-ft.	515 l. f.	2.00	2.14	2.50
24. 12-in. toe drain, 8-10-ft.	400 l. f.	2.50	2.14	4.00
25. Conn., existing drains	6 ea.	10.00	1.00	25.00
26. Steel sheet piling	1,880 s. f.	2.00	1.44	1.50
27. Railroad ballast	30 c. y.	5.00	1.80	3.00
28. Vault door and frame	2 ea.	150.00	110.00	175.00
29. Concrete pavement	2,110 s. y.	2.50	2.79	2.75
30. Bitum. pavement	1,160 s. y.	2.00	2.35	2.50
31. Gravel surfacing	620 s. y.	1.00	.40	1.00
32. Remov. exist. conc. pavmt.	2,110 s. y.	.40	.50	.40
33 Remov. exist. bitum. pavmt.	1,160 s. y.	.40	.35	.30
34 Remov. existing struct.	L. S.	125.00	85.00	100.00
35. Relocate house drains	L. S.	150.00	125.00	400.00
36. Seal trench filler	50 s. f.	1.00	.25	1.50

UNDERPASS, NORTH DAKOTA

OWNER: North Dakota State Highway Department, J. S. Lamb, commissioner; C. Johnson, engineer.

PROJECT: Construction of 55-ft. steel I-beam and concrete deck span underpass grade separation and approaches under Northern Pacific Railway tracks at 9th and Main Streets, Bismarck, N. Dak.

CONDITIONS: All materials to be furnished by contractor. Stipulated contract time 175 sixteen-hour days. Wage rates are: skilled 80c. per hr.; semi-skilled, 60c. per hr.; and common, 45c. per hr. There is, however, possibility of higher labor costs. Contract was awarded conditionally contingent upon rate change, and upon state election July 11.

BIDS: Eight bids were opened June 1, and letting was made June 30, 1939. Bids range from the low of $149,268 to $179,920. Engineer's estimate, $175,206.

LOW BIDDERS:

1. Minneapolis Bridge Co., Minneapolis, Minn. (conditional award) $149,268
2. Fielding & Shepley, St. Paul, Minn 152,469
3. Rue Constr. Co., Bismarck, N. Dak 155,301

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Unclass. excav	12,458 c. y.	$0.33	$0.40	$0.40
2. Struct. excav., paving	40 c. y.	.86	1.50	1.30
3. Class A-4 concrete	81.2 c. y.	19.10	24.00	24.00
4. Reinforcing steel	3,893 lb.	.05	.06	.06
5. 7-in. one crse. conc. pave.	6,051.6 s. y.	3.50	2.80	2.30
6. 6-in. integr. curb (curved).	211.4 l. f.	.39	.40	.45
7. 6-in. integr. curb (straight)	579 l. f.	.33	.40	.40
8. 12-in. integr. curb. (strght)	241.8 l. f.	.60	1.00	.80
9. Variable integral curb	280.5 l. f.	.87	1.50	.90
10. Rein. conc. sidewalk	764.9 s. y.	2.70	1.25	2.50
11. Concrete sidewalk	407.4 s. y.	2.56	1.00	2.00
12. 3-bar pipe railing	308.7 l. f.	3.51	2.50	3.00
13. Curb inlets, type A	2 ea.	58.75	40.00	35.00
14. Curb inlets, type B	4 ea.	18.80	50.00	60.00
15. Drop inlets	2 ea.	28.50	60.00	40.00
16. Manholes, under 12-ft.	4 ea.	133.70	100.00	150.00
17. Manholes, over 18-ft.	2 ea.	200.55	150.00	230.00
18. 8-in. vit. cl. pipe (open jt.).	972 l. f.	1.62	1.25	1.60
19. 8-in. vit. cl. pipe (cem. jt.).	280 l. f.	1.25	1.25	1.30
20. 12-in. rein. conc. pipe (cem. jt.)	276 l. f.	1.82	2.00	3.20
21. 15-in. rein. conc. pipe (cem. jt.)	1,367 l. f.	2.18	9.00	10.00
22. 8-in. c. i. soil pipe	60 l. f.	2.48	2.00	2.00
23. Adj. manholes to grade	4 ea.	43.30	15.00	15.00
24. Adj. catch basins to grade.	2 ea.	43.23	10.00	15.00
25. Adj. water valve to grade.	6 ea.	33.60	60.00	10.00
26. Adj. fire hydrant	1 ea.	48.30	60.00	40.00
27. Reloc., lower 8-in. wat. main	412 l. f.	1.05	2.25	3.50
28. Remove exist. pavmt.	5,378.6 s. y.	.19	.40	.40
29. Sodding	93 s. y.	.50	1.00	1.00
30. 3-ply membr. waterprfg.	12 l. f.	.44	.60	.32
31. Backfill	2,597 c. y.	.48	.50	.50
32. Structural excav	1,505 c. y.	1.48	2.00	2.00
33. Untr. piling, temp. br.	3,298 l. f.	.70	.70	.80
34. Untr. timber, temp. br.	51.8 M. bm	63.65	75.00	90.00
35. Tr. timber test piles	6 ea.	81.00	150.00	130.00
36. Tr. timber piles	9,686 l. f.	1.07	1.10	1.10
37. Class B concrete	846 c. y.	12.10	13.00	18.00
38. Class A-1 concrete	418 c. y.	21.35	20.25	20.00
39. Class A-2 concrete	715 c. y.	24.58	17.25	20.00
40. Class A-3 concrete	46 c. y.	40.00	35.00	28.00
41. Reinforcing steel	171,266 lb.	.06	.06	.055
42. Structural steel	242,701 lb.	.05	.055	.05
43. Pipe railing, bet. cols.	48.4 l. f.	1.43	1.50	1.50
44. Ornamental railing	113.3 l. f.	5.13	5.00	7.00
45. 3-bar pipe railing	651.2 l. f.	3.51	3.50	3.20
46. 2-bar pipe railing	451 l. f.	2.30	2.50	2.75
47. Asph. waterprfg. 1 coat	5,945 s. f.	.05	.05	.03
48. Asph. waterprfg. 2 coats	2,051 s. f.	.14	.07	.04
49. Asphalt planks	3,393 s. f.	.28	.30	.25
50. 2-ply membr. waterprfg.	3,393 s. f.	.26	.15	.10
51. 3-ply membr. waterprfg.	708 l. f.	.40	.60	.32
52. Lighting system	L. S.	2,125.50	2,000.00	1,000.00
53. High early str. conc.	193 c. y.	14.60	20.00	18.00
54. Rehandling materials	6,000 c. y.	.29	.15	.20
55. Gravel fill material	15,000 c. y.	.56	.40	.50
56. Pit run grav. ballast	4,000 c. y.	1.04	.70	.85
57. Washed gravel ballast	1,500 c. y.	1.10	1.50	1.00

HIGHWAYS, RONDOUT RESERVOIR, NEW YORK

OWNER: Board of Water Supply, City of New York, N. Y.; James A. Guttridge, engineer.

PROJECT: Construction of 8¼ miles of bituminous macadam, penetration method, highways; steel truss and girder highway bridge; concrete girder highway bridge; and appurtenances in Wawarsing, Ulster County, N. Y. Highways extend northwest from present State Highway 55 between Napanoch and Montela, approximately 5 miles from Napanoch and one mile south of proposed Lackawack Dam. Rondout Creek Bridge, steel truss and girder type 180-ft. long with 70-ft. girder approach spans at each end, carries westerly highway over Rondout Creek; concrete girder bridge carries easterly highway over Sawkill creek.

CONDITIONS: Highway and rail facilities available for transportation; Ellenville station of New York, Ontario and Western R.R. about 7½ miles from beginning of work. Contract to be completed in 24 months and contractor to furnish all materials. Approximately 3¼ miles of highway work to be 20 ft. wide, balance 18 ft. wide. Wage rates for skilled labor range from $1.00 for painters to $2.25 per hr. for hoisting engineers; for semi-skilled, from 62½c. for stone mason's helpers to $1.65 for concrete mixer operators; and for common labor, 75c. per hr.

BIDS: Four bids were opened on July 7, 1939, ranging from the contract low of $942,660 to $1,082,690.

LOW BIDDERS:

1. Ottaviano & MacDonald Inc., and A. E. Ottaviano, Inc., Croton-on-Hudson, N. Y. $942,660
2. Federal Constr. Corp., New York, N. Y. 1,023,414
3. George M. Brewster & Sons, Inc., Bogota, N. J. 1,079,570

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clear. and grub	L. S.	$12,000.00	$55,000.00	$65,000.00
2. Unclass. excav	325,000 c. y.	.60	.55	.70
3. Earth excav	12,500 c. y.	1.25	1.25	1.25
4. Rock excav	2,200 c. y.	4.00	10.00	6.00
5. Refill. and embank	325,000 c. y.	.10	.22	.10
6. Surf. dressing and grassing	25,000 c. y.	1.70	2.00	2.15
7. Prep. fine grade	93,000 s. y.	.10	.15	.06
8. Found. course	20,000 c. y.	3.00	3.05	3.85
9. Bottom course	10,500 c. y.	4.00	4.40	4.40
10. Top course	8,000 c. y.	4.50	5.32	4.05
11. Bituminous mat'l.	410,000 gal.	.08	.065	.09
12. Calcium chloride	40,000 lb.	.025	.025	.025
13. Conc. masonry	7,500 c. y.	13.00	11.00	19.30
14. Portland cement	17,000 bbl.	2.68	2.35	2.35
15. Membrane waterprf'g	1,700 s. y.	1.25	.97	1.35
16. Reinf. conc. pipe	4,200 l. f.	3.25	6.00	3.30
17. Vit. pipe	3,000 l. f.	.90	.96	1.05
18. Conc. piles	1,000 l. f.	5.50	6.00	.01
19. Timber, lumber	10 M bm.	90.00	100.00	130.00
20. Struct. steel	650,000 lb.	.06	.06	.067
21. Misc. cast, wrght. iron and steel	85,000 lb.	.22	.25	.15
22. Reinf. steel	350,000 lb.	.05	.05	.07
23. Sheet piling steel	500,000 lb.	.05	.02	.0001
24. Dry rubble, mason. and pav	3,000 c. y.	8.00	7.00	4.00
25. Rubble, mason. and pav., mortar.	3,000 c. y.	12.00	9.00	12.00
26. Crushed stone	11,000 c. y.	2.50	2.50	3.75
27. Rustic timber guard-rails	35,000 l. f.	1.00	.65	1.00
28. Found. Rondout Cr. bridge	L. S.	36,000.00	55,000.00	35,000.00
29. Falsew'k., Rondout Cr. br.	L. S.	3,500.00	7,000.00	2,000.00
30. Falsew'k., Sawkill Cr. br.	L. S.	15,000.00	30,000.00	23,000.00
31. Cleaning up	L. S.	10,000.00	2,000.00	2,500.00